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Draft guidance document on non-technical measures

Summary

The implementation of emission limit values may not always be sufficient to meet national emission reduction obligations or air quality targets. Additional actions, such as non-technical measures, can supplement efforts at the national or local level. The present document, prepared by the Task Force on Integrated Assessment Modelling in accordance with item 2.2.3 of the 2024–2025 workplan for the implementation of the Convention (ECE/EB.AIR/154/Add.1), discusses several options for non-technical measures and their potential contribution to environmental quality improvements. It defines the basic requirements for successful implementation, gives examples with proven success, and addresses the challenges of assessing costs and benefits. The focus of the measures in this document is on residential heating, mobility and food consumption.

The present document takes into account the comments submitted on the informal version of the document by Parties after the forty-fourth session of the Executive Body (Geneva, 9–12 December 2024). It is expected that the final draft of the document will be forwarded by the Working Group on Strategies and Review to the Executive Body for adoption at its fifty-fifth session (Geneva, 8–11 December 2025).

I. Introduction

1. The Working Group on Strategies and Review at its fifty-ninth session (Geneva, 18–21 May 2021) recommended developing a guidance document on “non-technical measures”,[1] which cover structural and behavioural measures, as well as policy action aimed at furthering such change. The development of the document is included in the 2024–2025 workplan for the implementation of the Convention (ECE/EB.AIR/154/Add.1, item 2.2.3). The guidance document should be based on best practices at the national level (focused on meeting national emission reduction obligations) and at the local or regional level (focused on reducing health and ecosystem damage).

2. Abatement of emissions under the Convention is mainly the result of regulation. There is a legal obligation to apply specific add-on technologies or to meet emission limit values, for example, for new installations and vehicles. It is relatively easy for air quality policymakers to assess the additional costs of potential technical abatement measures for certain sectors, and they can be compared with the expected benefits for health and ecosystems.

3. Contrary to technical measures for specific installations or vehicles, the implementation of structural innovations of industrial production processes, changes in final use of products or transitions towards more sustainable transport or food systems often require a mix of technical and behavioural changes, as well as a mix of policy instruments. Apart from regulation, the policy mix could include pricing, research investments, infrastructural planning and awareness-raising; in this guidance document, they are grouped together as “non-technical measures”.

4. The political assessment of costs and benefits of non-technical measures will often require broader involvement of stakeholders, other ministries than the ministry in charge of the environment, cities and the public at large. Benefits could entail more than better air quality. Climate benefits, safety improvements, additional health benefits due to physical activity, lower noise levels and less nitrate leaching are all potential co-benefits of non-technical measures. Conversely, the costs of such measures could entail more than out-of-pocket expenses. The loss of services, time, comfort, or freedom (e.g., choosing what to eat, how to heat accommodation, or how to move from point A to point B) are all potential societal costs. Successful implementation of non-technical measures will, at the very least, require more involvement of the public and of industries in the decision-making process. Acceptance of those measures will also depend on equity issues: Who pays and who will benefit? Will small enterprises disappear? Do farmers have to stop their activity? Will prices rise and will low-income groups still be able to pay their energy bills, access the city or afford healthy meals?

5. Decisions on non-technical measures will, in many cases, do more to raise political debate than to strengthen technical emission limit values. Implementation will probably require more time. The acceptability of such measures, as well as the acceptable mix of policy instruments, may vary across countries, depending on cultural and political preferences.

6. This guidance document discusses several options for non-technical measures and their potential contribution to environmental quality improvements. It defines the basic requirements for successful implementation, gives examples with proven success, and addresses the challenges of assessing costs and benefits. The focus of the measures in this document is on residential heating, mobility, food consumption and changes available to citizens rather than to companies, although companies can facilitate changes by citizens. The document builds on an earlier informal document prepared under the review of the Protocol to Abate Acidification, Eutrophication and Ground-level Ozone (Gothenburg Protocol). [2]

[1] ECE/EB.AIR/WG.5/126, para. 27.

[2] See https://unece.org/sites/default/files/2021-11/Informal%20doc%20on%20non-technical%20measures.pdf.

II. Why are non-technical measures necessary?

7. Implementation of technical emission limit values for installations, vehicles and products is not always sufficient to meet national emission reduction obligations or long-term air quality targets to protect human health and ecosystems. In such cases, additional actions in the form of behavioural change measures or changes in the structure of the economy could be considered: for example, non-technical measures that lead to lower use of fossil fuels, less car traffic, or fewer cattle. Such measures can be initiated at the local or national level but can also be backed by international coordination.

8. Non-technical measures could include faster replacement of old and polluting technologies with new and cleaner technologies, the use of cleaner fuels or feedstocks, or greener consumer behaviour. The latter could include a modal shift from private motorized to public or private non-motorized transport, dietary changes, or cleaner residential energy use. Sometimes such measures prove to be more efficient and less costly than implementing stricter emission limit values, but there can also be hidden non-monetary costs, such as longer travel time, less comfort, and loss of freedom in terms of choice of food.

III. Definitions

9. In this guidance document, non-regulatory consumption changes, production changes and product innovations not included in the technical annexes to the Gothenburg Protocol are referred to as "non-technical measures". The implementation of such measures involves various policy instruments, such as information campaigns, pricing, as well as regulatory measures, such as vehicle speed limits, which are equally grouped under the term "non-technical measures". This terminology is commonly found in the context of air pollution policy. In other forums, it is more common to use the terms "behavioural change measure", "structural change measure", or "demand-side measures", which represent roughly the same phenomena.

10. Despite the literal meaning of the term, these "non-technical" measures can still have technical components. For example, insulation of buildings, solar energy use, and the redesign of products and processes or advanced public transport systems are all technical examples. Examples of purely non-technical measures are reducing indoor temperature, lower vehicle speed, or a shift towards public transport, cycling and walking. There are also technical measures with a high behavioural component, such as improved maintenance routines (e.g., regular checking of pumps, valves and pipelines for leakages, checkups for cars, heating systems, etc.). Other examples of hybrid measures (technical "non-technical" measures) are motion-activated light switches, cruise control functionalities in vehicles, or certified product information so that people can be sure they select environmentally friendly dishwashers, refrigerators, wood stoves, etc.

11. Often, "non-technical measures" are associated solely with behavioural change. However, as illustrated above, they encompass much more. The most important aspect of the types of measures discussed in this document is that they are not regulated in the technical annexes of the Gothenburg Protocol. Given the possibility of narrow or potentially misleading interpretation of the terminology "non-technical measures", the broader terms "structural measures" or "structural changes" may be more appropriate when referring to measures that are additional to the end-of-pipe techniques prescribed in the technical annexes to the Protocol. The common feature of structural changes is that they cannot easily be implemented via permitting of specific activities. They often require a combination of actions by various players in the production chain, as well as by consumers. As the term "structural changes" suggests, it could even include a transition towards a new economic structure that is less reliant on the use of fossil fuels or animal-based food.

IV. Policy instruments to implement non-technical measures

12. Putting it simply, four types of policy instruments can be distinguished: regulatory; economic; social (information and communication); and public investments (including

research and development).[3] These instruments can be combined in several ways. Below are examples focusing on these four types of policy instrument in the transport system:

(a) Regulatory instruments: some cities have closed parts of their centre to cars or have withheld permits (e.g., for parking or for new roads). The 2020 coronavirus disease lockdown demonstrated that regulation of vehicle activity in the event of a societal emergency can be acceptable;

(b) Economic instruments: These could include a tax based on the pollution emitted by cars; subsidies for clean alternatives; innovation support for scaling up new technologies; compensation for the early scrapping of old vehicles; and increased parking fees in city centres;[4]

(c) Social instruments: These could include raising awareness and public involvement in monitoring and city planning, or incorporating communication strategies that suggest or promote a (modal) shift toward less polluting options. Such instruments may not always be sufficient to effectively change the individual behaviour of a sufficient part of the population but can improve societal support for the use of one of the other policy instruments mentioned above and contribute to adapting social norms that, in turn, influence individual behaviour;

(d) Public investments: These could include physical planning and targeted investment in infrastructure that could provide an important opportunity for the public sector to bring about structural change. For example, investment in public transport, the removal of parking spaces and the replacement of car lanes by bus or bicycle lanes have a proven effect on traffic intensity and on modal change, and thus on polluting emissions. Additionally, Governments could adopt policies to expand electric vehicle infrastructure, and to replace government motor vehicle fleets with electric vehicles.

13. Extensive research has been carried out into the optimal mix of policy instruments, including by political scientists, economists and other social scientists, such as psychologists and even neurological researchers.[5] Efforts to find a theoretical optimal policy mix do not lead to a single answer. Much depends on the actual preferences and power of stakeholders. In practice, pragmatic policy choices are sometimes made that acknowledge limited public acceptance of certain policy instruments, as well as the fact that long-term goals cannot be realized at once and that policymakers sometimes must start by taking small steps in the right direction.

V. Inventory of effective non-technical measures

A. Energy

14. Explorations of the potential emission reductions from structural changes in the energy sector are well covered by energy models such as the Price-Induced Market Equilibrium System (PRIMES). The results of energy scenarios show that a shift from fossil fuels to renewables such as wind and solar energy could significantly reduce fuel-related emissions such as sulfur dioxide (SO_2), nitrogen oxides (NO_x), particulate matter ($PM_{2.5}$) and black carbon (BC). Such co-benefits from climate and energy policies are included in the Greenhouse Gas – Air Pollution Interactions and Synergies (GAINS) scenarios developed by the Centre for Integrated Assessment Modelling (CIAM). However, the side effects of climate measures will not always be positive. The use of carbon capture and storage would require substantially more energy, and this could increase NO_x emissions if no additional add-on technology is used. Also, the use of hydrogen or ammonia as energy carriers would require additional (technical) measures to minimize an increase in emissions of air pollutants.

[3] Awareness-raising and research and development are necessary instruments, but insufficient when applied on a stand-alone basis. Their impacts are indirect and therefore difficult to quantify.

[4] See ECE/EB.AIR/118.

[5] See https://implementconsultinggroup.com/article/harness-the-potential-of-habits-at-work; and www.visualcapitalist.com/wp-content/uploads/2017/09/cognitive-bias-infographic.html.

Moreover, biomass burning in the residential sector can increase $PM_{2.5}$ emissions, depending on the fuels it replaces. These side effects are covered in the GAINS scenarios, which is not always the case for calculations of non-technical measures to reduce emissions from residential heating, transport and food.

B. Residential heating

15. Emissions from wood stoves are the combined result of technical standards and wood burning behaviour. For the reduction of emissions from domestic wood burning (a coherent package of) "non-technical" measures are likely to be more effective and suitable than technical measures. Examples of such measures, together with the policy instruments thought to induce them, are:

(a) Public investment programmes providing grants, incentives or rebates to accelerate the removal or replacement of old and polluting wood burning appliances (e.g., in Poland and Denmark);

(b) Regulatory policies for prohibiting use of all, or less efficient, devices during high pollution events (e.g., in some parts of the Kingdom of the Netherlands and the United States of America);

(c) Social instruments: training programmes for proper installation and regular maintenance schemes (e.g., the role of chimney sweepers in Germany);

(d) Social instruments: encouraging good burning practices and the use of dry wood (e.g., in the United Kingdom of Great Britain and Northern Ireland);[6]

(e) Economic and social instruments incentivizing energy renovation (reducing heat demand), etc. (e.g., in Italy).[7]

16. All these measures will likely be more cost-effective than retrofitting existing domestic wood burning equipment stock with a catalyst or an electrostatic precipitator and other technical abatement measures (for more information, see Code of good practice for wood burning and small combustion installations (ECE/EB.AIR/2019/5)).

17. In many countries, there are efforts to raise awareness of the indoors and outdoors health risks of wood burning to stimulate voluntary action. Awareness-raising is often a necessary first step to change behaviour and this can help in the acceptance of regulations on how and when to burn wood should awareness-raising alone prove to be insufficiently effective. Several countries or cities go beyond awareness-raising, for example:

(a) The United States Environment Protection Agency certifies residential wood stoves that meet emission limits and efficiency requirements. In this case, the Government has a unique role as a trusted third party;

(b) German chimney sweepers check that households engage in correct wood burning behaviour;

(c) Some States in the United States of America have banned the burning of wood in the event of an unfavourable weather forecast (such as low wind speed or inversion);

[6] Department for Environment, Food and Rural Affairs (DEFRA), "Selling manufactured solid fuels for domestic use in England", GOV.UK,7 July 2022, available at www.gov.uk/guidance/selling-manufactured-solid-fuels-for-domestic-use-in-england and: DEFRA, "Getting fuel authorized for sale in smoke control areas", GOV.UK, 7 July 2022, available at www.gov.uk/guidance/selling-fuel-in-smoke-control-areas.

[7] Laura Canale and others, "About the effect of tailored energy feedback on space heating consumption and indoor air temperature in social housing buildings: An experimental investigation", *Energy and Buildings*, vol. 292 (August 2023).

(d) Some cities in the Kingdom of the Netherlands have introduced wood-burning-free neighbourhoods, or give warnings to stop the burning of wood (voluntary) when weather conditions are unfavourable;[8]

(e) Several countries provide financial compensation for scrapping old wood stoves, such as Belgium and Denmark.[9] Poland has a comparable programme to scrap coal stoves;[10]

(f) Several countries focus their information campaigns on the health impacts of wood burning. Such campaigns not only show the health impacts of outdoor air pollution on neighbours, but also the impacts of indoor exposure on family members, especially children.[11]

18. These are all examples of policies to further reduce emissions from wood stoves in addition to technical standard setting.

C. Transport

19. Measures at the national level to implement non-technical measures include: programmes to expand electric vehicle infrastructure and provide incentives for increasing electric vehicle sales; logistical programmes to reduce emissions from goods transport; national speed limits; increases in fuel duties; national road pricing; investments in public transport; agreements with cities on low-emission zones; scrapping schemes; and public awareness-raising on the health benefits of active mobility (walking and cycling).

20. There are several inventories of promising local traffic measures,[12] and review reports.[13]

21. One study identifies 58 unique local measures (or interventions),[14] of which 20–25 per cent are mainly technical (vehicle emission regulation, retrofitting, inspection and maintenance). Of the non-technical measures identified, 14 per cent were related to the use of pricing instruments (parking charges, road pricing, fuel taxation), 8 per cent to awareness-raising (promotion of public transport, active mobility, car sharing), 14 per cent to

[8] Amersfoot, "Stook geen hout bij code rood of oranje", available at www.amersfoort.nl/stook-geen-hout-bij-code-rood-oranje#wat-te-doen-bij-overlast-9866 (Dutch only).

[9] Heidi Ravnsborg/Danish Ministry of Environment, Domestic heating in DK (wood stoves regulation and behaviour design), available at https://unece.org/sites/default/files/2023-09/Agenda%20item%20%285%29%20Domestic%20heating%20in%20Denmark.pdf.

[10] LIFE Małopolska, "Anti-smog resolution for Krakow", available at https://powietrze.malopolska.pl/en/anti-smog-resolution/krakow/.

[11] See, for example, results of indoor air quality measurements in Climate and Clean Air Coalition, "Pollution from residential burning: Danish experience in an international perspective", 2016, available at www.ccacoalition.org/resources/pollution-residential-burning-danish-experience-international-perspective.

[12] Haneen Khreis and others, "Urban policy interventions to reduce traffic-related emissions and air pollution: A systematic evidence map", *Environment International*, vol. 172 (February 2023); and Paula Kuss and Kimberly Nicholas, "A dozen effective interventions to reduce car use in European cities: Lessons learned from a meta-analysis and transition management", *Case Studies on Transport Policy*, vol. 10, No. 3 (September 2022), pp. 1494–1513.

[13] See Public Health England, *Review of Interventions to Improve Outdoor Air Quality and Public Health* (London, 2019); Institute of Occupational Medicine, *Rapid Evidence Assessment of Interventions to Improve Ambient Air Quality: Social Science/Behavioural Interventions*, Report No. 745-5 (n.p., 2018); Supplementary material to Public Health England (2019): Reports REA1 (Industry), REA2 (Structural/Planning Interventions), REA3 (Transport), REA4 (Agriculture), REA5 (Social Science/Behavioural Interventions), available at https://app.box.com/s/kt5m8gugipky7lif3xyskjjwf3o5s1m6; Helmut Lorentz and Wolfgang J. Müller, *Guideline on Air Quality Plans* (German Environment Agency, Dessau-Rosslau, 2016); Urban Agenda for the EU, *Code of Good Practices for Cities' Air Quality Plans: Part IV – Inspiring Examples* (Milan, Agency for Mobility, Environment and Territory, 2018), and J. Burns and others, "Interventions to reduce ambient air pollution and their effects on health: An abridged Cochrane systematic review", *Environment International*, vol. 135 (February 2020).

[14] Kreis, "Urban policy interventions".

infrastructural investments (public transport, bicycle lanes, speed bumps, roadside vegetation) and 5 per cent to city planning (transit-oriented development).[15] The remaining 59 per cent of the non-technical measures were related to regulatory instruments (low-emission zones, speed limits,[16] traffic circulation, imposed local fleet management).

22. Evaluation of the potential outcomes of such interventions is often based on qualitative judgement of feasibility and effectiveness or on (ex ante) modelling results. Examples of ex-post measurements of the outcomes in terms of reduced pollutant emissions and exposure or health improvements are limited, and such outcomes also depend on local circumstances. This complicates the inclusion of impacts of such local interventions in a coherent, quantitative, multi-country modelling framework such as GAINS.

23. One exception is the measurement of the impact of low-emission zones on exposure and health impacts.[17] However, here (at least part of) the impacts are decreasing over time, since older vehicles will have to be replaced anyhow at the end of their lifetime. Also, for the impact of interventions such as planting trees and shrubs and the use of catalytic paint measurements studies are available.[18] The impact of the use of photocatalytic pavements on NO_x concentration at the breathing level of pedestrians is small. The impact of urban vegetation on NO_x concentrations depends on several factors (urban morphology, location and configuration of green infrastructure, vegetation species, local meteorology, traffic emissions in nearby streets, etc.). Impacts are very heterogeneous at pedestrian level. Vegetation can have a positive impact if adequate green infrastructure configurations are planted in the right locations. For example, vegetation barriers close to roads can be an effective measure for reducing exposure of pedestrians to air pollutants. The impacts of planting trees on streets should be investigated for each situation.

24. In general, promotion of cleaner vehicles and limitation of car traffic will be the most effective measures in reducing exposure to NO_2 and primary $PM_{2.5}$ in a given city. Limitation of car traffic would also reduce non-exhaust pipe emissions, such as tire-, break- and road-wear. Limited low emission zones and traffic circulation plans to reduce exposure at so-called hotspots could increase exposure in other parts of the city. Emissions and average exposure (and total health damage) could even increase, depending on the new circulation plan and whether traffic increases are expected in populated areas due to route changes. For $PM_{2.5}$, the average exposure in many cities depends largely on emission sources outside the city, such as industry, motorways, shipping and agriculture (through secondary particles formed by ammonia emissions). The impact of traffic measures within a given city will therefore only have a modest effect on the average exposure to $PM_{2.5}$ in said city.

[15] In general, speed bumps are not (only) meant to reduce pollution, but also to improve safety. Infrastructural measures are mainly designed to improve traffic flows, but could also reduce traffic in living areas (see Natalie Mueller and others, "Changing the urban design of cities for health: The superblock model", *Environment International*, vol. 134 (January 2020)), although they could also increase emissions. Roadside vegetation will not reduce emissions, but could marginally reduce exposure to pedestrians and cyclists (see LIFE+RESPIRA, *Final Report Covering the Project Activities from 01/06/2014 to 31/12/2017*, Report No. LIFE13 ES/ENV/417, available under tab "Project's Final Technical Report" at https://webgate.ec.europa.eu/life/publicWebsite/project/LIFE13-ENV-ES-000417/reduction-of-exposure-of-cyclists-to-urban-pollutants).

[16] 30 km speed limits in Berlin proved to reduce exposure to NO_2 by PM10 2-4 µg/m^3 locally: European Environment Agency, "Traffic management in Berlin, Germany", available at https://www.eea.europa.eu/publications/managing-air-quality-in-europe/traffic-management-in-berlin-germany; see for the effect of 100 km speed limit on highways: I. D'Elia and others, "Evaluation of mitigation measures for air quality in Italy in 2020 and 2030", *Atmospheric Pollution Research*, vol. 9, No. 6 (November 2018), pp. 977–988.

[17] Mayor of London, *Expanded Ultra-low Emission Zone: Six Month Report Including Low Emission Zone – One Year Report* (n.p., 2022); I. D'Elia and others, "Technical and Non-Technical Measures for air pollution emission reduction: The integrated assessment of the regional Air Quality Management Plans through the Italian national model", *Atmospheric Environment*, vol. 43, No 39 (December 2009), pp. 6182–6189; German Environment Agency, "Low-emission zones in Germany"; and Transport and Environment, Low-emission zones are a success – but they must now move to zero-emission mobility (n.p., September 2019).

[18] LIFE+RESPIRA, *Final Report.*

25. City-level decision-makers could still learn from experience sharing between cities and between national and international experts and policymakers.[19] Effective interventions to reduce car use in cities differ among cities and countries. In some cities, pricing measures proved to be effective, for example, in Stockholm, New York and the congestion tax in London, while in other cities this measure was judged as politically unacceptable because it could increase social inequalities. In other countries, infrastructural changes, such as providing more public transport, removing parking places and downgrading main roads, prove to be more acceptable from a social policy point of view. Clearly, there is not one silver bullet solution for all countries.

D. Food

26. For transforming the food system, the most effective non-technical measure is to support a transition towards healthy plant-based diets and reduce dairy and meat consumption and production. This can be achieved by collaborative efforts to improve food environments[20] to make healthy and sustainable food options affordable, accessible and acceptable. This could form a powerful way to reduce emissions of ammonia and methane. It would offer the opportunity for a structural shift towards less intensive farming, which would also contribute to biodiversity restoration and improved water quality. Other relevant and effective measures related to emissions from food production are continued bans on agricultural waste burning, improved routines for mineral fertilizer application, and improved manure management practices.[21]

27. A recent Task Force on Reactive Nitrogen report entitled “Appetite for Change: Food System Options for Nitrogen, Environment and Health”[22] shows how an effective mix of policy instruments could look when changing the food system, including diets. Changing diets, if followed by reduced dairy and meat production, would reduce nitrogen losses, and have co-benefits for nutritional quality and public health. The main message is to engage all stakeholders in the decision-making process and in policy evaluations to address unintended effects of policies. Recent farmer protests in Europe show how important this is. Farmers and rural communities require new economic incentives if industrial farming is restricted. An agreement with large feed and seed producers, food traders, supermarkets and banks would also be needed.

28. Several (voluntary) bottom-up approaches to sustainable food systems are emerging at the local and regional levels. However, large-scale reductions in meat and dairy consumption are not yet visible in agricultural statistics. Nonetheless, there are significant differences in meat consumption across the ECE region, partly explained by differences in income, but also by cultural differences in diets. The latter factor suggests that the promotion of recipes from countries with low-meat diets (such as some Mediterranean and Nordic countries) could create an appetite for change in broader parts of the ECE. Of course, potential risks associated with vegetarian diets should also be considered.[23]

29. The above-mentioned report shows that a policy target aimed at prescribing vegan or vegetarian menus would lead to relatively high societal costs due to a perceived loss of freedom to choose what to eat. Instead, stimulating partial vegetarian (demitarian) menus

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[19] “Clean Air in Cities: Position paper from the Expert Panel on Clean Air in Cities (EPAC) under the UNECE’s Air Convention (CLRTAP) Task Force on Integrated Assessment Modelling (TFIAM)”, 27 November 2024, available at https://iiasa.ac.at/sites/default/files/2024-12/EPCAC_Position_Paper_27nov2024.pdf.

[20] The term “food environment” refers to the availability and visibility of (un)healthy food products in streets and shops.

[21] For additional information, see Markus Amann, ed., *Measures to Address Air Pollution from Agricultural Sources*, International Institute for Applied Systems Analysis (IIASA) Report (IIASA, 2017).

[22] Adrian Leip and others, eds. (Edinburgh, United Kingdom Centre for Ecology and Hydrology, 2023). Available at www.clrtap-tfrn.org/sites/default/files/2025-01/clrtap_AppetiteforChange_report.pdf.

[23] Ursula M Leonard and others, “Impact of consuming an environmentally protective diet on micronutrients: a systematic literature review”, *The American Journal of Clinical Nutrition*, vol. 119, No. 4 (April 2024), pp. 927–948.

would be optimal from a societal cost point of view. They would achieve substantial reductions of nitrogen waste, thereby reducing the need for costly farm-level (technical) measures. The overall societal benefit of such mixed policy measures is higher than for measures excluding such dietary changes. Nevertheless, the scientific consensus on the health impacts of too much meat consumption and of its impact on animal welfare, nitrogen losses to the environment and its contribution to climate change is, in several countries, driving the need to develop national food strategies that affect dietary change. Awareness-raising is a necessary first step for the acceptance of policies that affect dietary choices, but such a policy strategy will need to include regulatory or financial measures and be supported by research and innovation in sustainable food. For the moment, dietary change via food labelling and dietary guidelines seems to be relatively acceptable but has shown little effect so far. Some countries have gone further. Austria has subsidized organic food and, in 2024, Denmark proposed the introduce of a carbon tax on livestock.[24] There are also emerging collaborative efforts between associations of diet advisors, universities and food retailers to commercialize sustainable food and many retailers are setting plant/animal targets for their protein sales.[25]

E. Conclusions

30. There is no silver bullet solution when it comes to the most effective non-technical measures and their implementation. What is acceptable in one country or city will not always work elsewhere; for example, road pricing seems to be more acceptable in some countries, but encounters protests in others. Effective instruments aimed at individual behavioural change seem to encounter the most societal and political resistance. Policies that involve a change in transport behaviour seem to be less acceptable than measures to stimulate the use of cleaner vehicles. Wood burning and meat consumption seem to be regarded as human rights by many people, and non-technical measures in these fields often lead to fierce political debate.

VI. Modelling potentials, costs and benefits of structural and non-technical measures

31. Discussions on structural changes have taken place over many years. The 2007 Task Force on Integrated Assessment Modelling/Centre for Integrated Assessment Modelling report on the review of the Gothenburg Protocol concluded that: "In addition to available end-of-pipe emission control measures, non-technical and local measures will be of increasing relevance, especially if multiple policy objectives are pursued."[26]

32. This conclusion is still relevant and has become even more pertinent in terms of being able to meet the long-term targets of the Convention. But how much could such measures contribute to a low pollution environment? How much would they cost compared to technical measures? What are their benefits?

33. Recent scenario modelling by CIAM with the GAINS model sheds some light on the first question. CIAM developed a "LOW" scenario (i.e., application of maximum technically feasible reduction (MTFR) controls, plus consistency with a Paris Agreement greenhouse gas emission pathway, plus inclusion of structural changes, as well as dietary shifts). This was compared with a MTFR scenario in which mainly end-of-pipe measures are used to reduce emissions. The LOW scenario shows further reduction of agricultural emissions of methane and ammonia compared to the MTFR scenario. Compared to the baseline, by 2030, almost

[24] See, e.g., Hanna Ziady, "World's first carbon tax on livestock will cost farmers $100 per cow", CNN, 27 June 2024, available at https://edition.cnn.com/2024/06/26/business/denmark-cows-carbon-tax/index.html; and, for an earlier proposal, S. Smed and others, "The effects of the Danish saturated fat tax on food and nutrient intake and modelled health outcomes: an econometric and comparative risk assessment evaluation", *European Journal of Clinical Nutrition*, vol. 70, No. 6 (April 2016), pp. 681–686.

[25] Susanna Kugelberg and others, "Implications of a food system approach for policy agenda-setting design", *Global Food Security*, vol. 28 (March 2021).

[26] Centre for Integrated Assessment Modelling (CIAM) Report 1/2007 (n.p., 2007).

160 million more people in the ECE region could be living in areas where concentrations of fine particulate matter are below 5 µg/m^3 if emissions followed the LOW scenario. In the MTFR scenario this would be 110 million more people.[27]

34. The climate community also delved into the issue of non-technical measures. The Sixth Intergovernmental Panel on Climate Change Assessment Report gives an indication of the potential contribution of structural and behavioural “demand-side” changes to emission reductions of greenhouse gases.[28] It shows that the potential contribution of dietary change (i.e., implementation of the healthy Willett diet)[29] could be as large as all measures to reduce residential fossil fuel use put together. A reduction in fossil fuel use is linked to emission reduction of both greenhouse gases (CO_2) and air pollutants (PM, SO_2 and NO_x). The same holds true for dietary change towards less meat and more plant-based production that will reduce emissions of methane and N_2O, as well as of ammonia (an important precursor of the formation of secondary PM). More specifically, the analysis shows that (non-technical) “demand-side” measures aimed at a shift from animal- to plant- based proteins could have the largest effects on greenhouse gas emissions, followed by demand-side measures aimed at buildings and transport (such as less heating and less driving). In relative terms, by 2050, non-technical measures could potentially reduce greenhouse gas emissions from food production by around 40 per cent (including methane and ammonia emissions) and energy use in buildings and transport by 25 per cent (including the associated NO_x emissions).

35. Overall, both GAINS modelling and climate scenarios show a large emission reduction potential by non-technical measures in 2050. This explains the interest in the feasibility of including these types of measures in air quality policies, as well as in the cost optimized scenarios developed with the GAINS model. To sum up, the expected benefits of including non-technical measures are:

(a) Non-technical measures will lead to lower air pollution, or to lower air pollution control costs to reach certain objectives than if estimated based on end-of-pipe measures alone;

(b) Structural change could play a key role in further reducing emissions in sectors such as domestic wood combustion, transport and agriculture;

(c) By reducing emissions of air pollutants and greenhouse gases simultaneously, non-technical measures will have larger (synergetic) reduction potentials than simple add-on controls that address mainly one pollutant;

(d) Given policy developments in other areas (climate, energy, nutrient management, transport, agriculture, biodiversity, etc.) it is more prudent to consider other measures than only technical end-of-pipe techniques (emission limit values in the technical annexes). A switch to cleaner fuels and cleaner technologies, energy saving and energy efficiency action, structural changes in transport or agriculture, behavioural changes in diets, modal shift to public transport, etc. could prove to be more cost-effective than applying end-of-pipe technologies. This may reduce the relevance of setting stricter emission limit values to further reduce emissions in the longer term.

36. In general, GAINS cost optimizations do not (yet) consider the potential of non-technical and local measures. GAINS has a focus on add-on technical solutions (measures with direct impact on the emission factors). Structural changes can be simulated by introducing changes in the baseline activity level projections (i.e., for energy, agriculture, etc.), as shown above in the comparison of the impacts of the LOW and MTFR scenarios for human health. Such simulations require the analyses to use a set of linked Europe-wide

[27] ECE/EB.AIR/WG.5/2024/INF.4, available at https://unece.org/sites/default/files/2024-05/Agenda%20item%20%282%29%20Draft%20policy%20brief%20health%20ecosystems.pdf.

[28] Intergovernmental Panel on Climate Change, *Climate Change 2022: Mitigation of Climate Change – Working Group III Contribution to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change – Summary for Policymakers* (Cambridge and New York, Cambridge University Press, 2022), p. 35.

[29] Professor Walter Willett and others, “Food in the Anthropocene: the EAT–Lancet Commission on healthy diets from sustainable food systems”, *The Lancet*, vol. 393, No. 10170 (February 2019), pp. 447–492.

models, for example, for energy use (PRIMES), agriculture (Common Agricultural Policy Regional Impact Analysis (CAPRI)) or transport (Calculations of Emissions from Road Transport (COPERT)). Additionally, input from national and local experts on envisaged or potential structural changes in their country or city would be valuable.

37. Efforts to include structural and behavioural changes in decision support models such as GAINS and in cost optimization still face challenges, some of which relate to modelling of emission reduction potentials, such as:

(a) Determining how to translate local experiences into reliable estimates of the measure implementation rates and potential emission reductions applicable for the whole ECE domain;

(b) While the implementation rates of end-of-pipe measures are predictable in modelling and verifiable (ex post), the degree of application of measures aimed at behavioural change is less predictable or verifiable with reasonable certainty (i.e., measures aimed at a modal shift from private cars to public transport, or the promotion of best practices in residential wood burning). This also hampers the estimation of the related costs.

38. Other modelling challenges relate more to the modelling costs of the measures:

(a) The costs of integrated city transport planning (e.g., a metro connection to a new neighbourhood) are difficult to attribute to air pollution, climate and urban accessibility, respectively. The same holds true for the related benefits. Here, assumptions made for the attribution of costs to the various goals could have a substantial impact on the relative cost effectiveness of such structural measures for reducing air pollution;

(b) Furthermore, what are the undesired welfare effects of behavioural changes? To be consistent, such welfare effects should be included as "costs" in GAINS-model cost optimization. Examples of relevant negative welfare effects that are yet to be estimated are effects on leisure time, comfort, level of services, or degree of self-determination (i.e., freedom of choice). Of course, some non-technical measures might imply desired welfare effects (in addition to the desired effects on air quality and deposition) that can balance out the undesired effects. Examples are effects on health from active travel modes, and reduced travel time in congested cities. Several studies have made theoretical assumptions regarding how to monetize non-monetary costs, but more development would be beneficial.[30]

39. One of the emerging challenges related to modelling of emission reduction potentials and costs is to find answers to questions such as the following:

(a) How much additional effect of non-technical measures is needed to meet WHO-guideline values or critical loads after all technical measures have been implemented? How much traffic reduction or reduction of livestock would be required and where?

(b) What will be required in terms of public expenses for enforcement and how much public money will be needed to convince citizens and industries to adapt their consumption choices and behaviour? Whilst this is not an important cost item for technical measures, it may well represent a considerable share of overall costs to reach specific structural and behavioural changes;

(c) What is more cost-effective: additional local measures or additional national and international measures?

(d) How high should financial incentives be to achieve sufficient behavioural change? In order to define the optimal level for a levy that covers the external costs created by pollution linked to a given choice or behaviour, the (policy) costs of implementing the measure in question also need to be known, as well as the behavioural resistance by those who need to change their behaviour.

[30] Claudio Carnevale and others, "Evaluating economic and health impacts of active mobility through an integrated assessment model", *IFAC-PapersOnLine*, vol. 51, No. 5 (January 2018), pp. 49–54; and Stefan Åström, *How to Express Socioeconomic Costs of Pro-environmental Behavioural Change?: A Suggestion for Cost-Benefit Analysis Purposes*, Report No. C868 (n.p., Swedish Environmental Research Institute, 2024).

40. In addition, more efforts are needed to understand the perceived welfare effects of structural changes and individual behavioural changes. Both diets and domestic wood combustion are household decisions and incentives from the public sector to change these behaviours are often met with strong opposition from citizens, despite their cost-effectiveness.[31]

VII. Political and social challenges of non-technical measures

41. As for all emission control options, there are certain challenges and limitations affecting successful and effective implementation of non-technical measures. This chapter groups these challenges and limitations into challenges and limitations in the political and social spheres. Financial challenges are also relevant but require little clarification. Some of the challenges are similar to those of the above-mentioned modelling. However, it is important to stress that non-technical measures are not only a challenge for modellers; special attention is also needed by decision-makers when contemplating implementing such measures.

A. Political challenges and limitations

42. The political challenges and limitations vary between different "types" of non-technical measures. For non-technical measures that are technical or hybrid in nature but are not based on emission limit values (such as building insulation, installation of solar panels, redesign of products, behaviour-inducing technologies), many of the political challenges and limitations relate to coordination barriers between policy spheres (to borrow language from innovation system sciences).[32] For these types of non-technical measures, coordination between climate, energy and air pollution policymakers, departments and agencies is important for successful implementation. The importance of coordination between these policy spheres has long been stressed but can be considered as especially important for these technical and hybrid non-technical measures. Here it is assumed that policymakers from different spheres are aware of the co-benefits of these technical and hybrid control measures. If this assumption is erroneous, it will also be important for coordination to be complemented by efforts to increase the awareness of co-benefits between spheres.

43. Furthermore, one challenge for all types of non-technical measures is that the effective policy instrument will vary and most often it is likely that policy instruments must be combined for effective implementation. For example, road charging (an economic instrument) benefits from being combined with awareness-raising (a social instrument). These instruments will also have to be aimed at several types of actors in the value chain of a product or service (energy and raw material providers, industrial manufacturing, transport providers, industry networks, final consumers). In general, for regulatory instruments the effectiveness is below but rather close to 100 per cent, although often assumed to be 100 per cent. For pricing, effectiveness depends on income and price sensitivities and will thus differ among countries and targeted behaviours. Voluntary tools (information and infrastructural investments) will not have a significant effect if not combined with regulation or pricing. However, they are a necessary precondition for the acceptance of regulation and pricing.

44. In addition, it is complicated to predict implementation, compliance and effectiveness of several non-technical measures. For example, effectiveness of road charging schemes must be evaluated through counterfactual analysis of how traffic intensity could have evolved if

[31] E.g., the potential emission reductions and associated health benefits of changes in wood burning behaviour can be very significant. For example, the United States Environmental Protection Agency (EPA) estimated that the health benefits of reducing $PM_{2.5}$ emissions from the residential wood combustion sector are in the order of $400,000 per ton. See EPA, *Technical Support Document: Estimating the Benefit per Ton of Reducing $PM_{2.5}$ Precursors from 17 Sectors* (n.p., 2018). Available at www.epa.gov/sites/default/files/2018-02/documents/sourceapportionmentbpttsd_2018.pdf.

[32] Åsa Löfgren and Johan Rootzén, "Brick by brick: Governing industry decarbonization in the face of uncertainty and risk", *Environmental Innovation and Societal Transitions*, vol. 40 (September 2021), pp. 189–202.

the road charge had not been introduced, or via comparison with past traffic intensities. But traffic intensities are a function of several parameters that might change during the implementation phase. Another impediment to prediction is the challenge related to the substantial number of emitting units affected by the measure. Changes in driving patterns will be the product of millions of car drivers changing ever so slightly, and incentives for clean burning will also, in some countries, affect millions of stove users. A final challenge in terms of predictability is the human response. Humans are famous for not behaving like *Homo economicus* (economic man). Many other psychological factors, such as preferences, affect the outcome, as well as the level of knowledge of all impacts of a given behaviour. For non-technical measures aimed at companies, stakeholder market power can, for example, affect the response to changes in incentives.

45. Moreover, for non-technical measures it is harder to prove their cost-effectiveness if applying a "welfare economic" lens. This is because there are non-monetary costs involved. Examples of such welfare aspects include longer travel time, less comfortable indoor temperatures and loss of "choice autonomy". There are of course non-monetary benefits involved, but these are already largely incorporated into the decision support modelling delivered to the Convention through the monetization of positive effects on human health.

46. Overall, regarding political challenges and limitations, it can be recommended that, for non-technical measures, pragmatic policy choices must be made. These choices must acknowledge that: public acceptance of such measures has limitations; long-term goals cannot be realized at once; and one should be satisfied with gradual change in the right direction.

B. Social challenges and limitations

47. Implementation of non-technical measures has challenges and limitations that vary in nature compared to the challenges and limitations of implementing technical measures. Some challenges are similar, such as investments and maintenance costs needed to align social drivers facilitating the desired measure, such as costs for construction of bicycle paths to facilitate a modal shift from cars to bicycles. Other challenges are different, such as establishing knowledge on where there are populations with demographic and cultural prerequisites for pro-environmental behavioural interventions.

48. Furthermore, it is important to recognize that non-technical measures that imply a challenge towards current social norms will be difficult to enforce. One of the reasons for this can be the fact that pro-environmental information campaigns often send a message that runs counter to social norms (such as consumerism and individualism) and price signals.[33] Furthermore, policies will have to consider characteristics such as cost-effectiveness, total costs, cost distribution, moral implications and diversity of possible consequences.

49. For climate policies (at least), it has been suggested[34] that the amount individuals would be willing to pay increases if the policy is effective and has a high probability of success. Also important is the fact that ancillary benefits (such as air pollution reduction) are well identified. Potential revenues from a given project should be reinvested in environmental protection and the "polluter pays" principle should be followed. Furthermore, policy instruments such as subsidies for pro-environmental products and services are preferred to penalties for polluting products and services.

50. The available evidence and theories, briefly described above, suggest that policies aimed at individual behavioural change are more likely to be acceptable if the individual is:

(a) Aware of and concerned about the problem to be solved by the policy;

(b) Aware of the most tangible consequences of the problem if it is not solved;

[33] Susan Owens and Louise Driffill, "How to change attitudes and behaviours in the context of energy", *Energy Policy*, vol. 36 (December 2008), pp. 4412–4418.

[34] Iva Zvěřinová, Milan Ščasný and Eva Richter, *What influences Public Acceptance of the Current Policies to Reduce GHG Emissions?* (n.p., n.d.).

(c) Feels a moral obligation to contribute to the solution;

(d) Perceives the proposed policy as fair and environmentally effective;

(e) Trusts the institution from which the policy proposal originates.[35]

51. In general, policy proposals are discouraged if they imply considerable influence on individuals' personal behaviour and if the policy would restrict personal freedom.

VIII. Conclusions

52. This document gives a concise overview of the potential emission reductions from structural changes and non-technical measures that can be considered during the revision of the Gothenburg Protocol. Further contributions are foreseen from the Task Force on Reactive Nitrogen, the Task Force on Techno-economic Issues and Parties.

53. There is still much to learn from one another. Effective interventions to induce behavioural change differ among countries. This was demonstrated with the example of road pricing to reduce vehicle use in cities, which proved to be highly effective in some countries, while in other countries the measure was not acceptable due to its expected social consequences. In some countries, infrastructural changes, such as more public transport, removal of parking places and narrowing of main roads, proved to be more acceptable than road pricing policies. This shows that there is no single silver bullet solution.

54. Measures with the largest potential impact in terms of emission reductions, such as dietary change, also seem to encounter the most resistance among the public and farmers. Restrictions on wood burning meet significant opposition in all countries, although the health benefits are clear.

55. There are also challenges in terms of quantifying ex ante the potential benefits and costs of various non-technical measures, both in terms of impacts on emissions, health and the environment, and in terms of costs of implementing and enforcing such measures. Country culture and history are likely to play a role in the uptake and acceptability of a given non-technical measure. This difficulty, as well as the fact that costs and benefits are likely to differ between countries and locations, presents a challenge also for including non-technical measures in optimized policy scenarios, as modelled for example in GAINS.

56. For the Gothenburg Protocol revision, it is worth discussing whether a less optimized intermediate approach could consist of estimating permissible livestock numbers and traffic densities, and how much wood could be burned in a given residential area (after all technical GAINS measures have been implemented) whilst still achieving air quality corresponding to WHO air quality guideline values.

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[35] Åström, *How to Express Socioeconomic Costs*.