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Ten years of ForFITS implementation

Note by the secretariat

Summary

This document summarizes the activities and achievement of the For Future Inland Transport Systems (ForFITS) tool since its inception in 2012, focusing on the activities since 2015, once the United Nations Development Account (UNDA) funding for the project stopped. It details how the model has been used and applied in recent years and how the project is expected to evolve in forthcoming years. The secretariat prepared the document following a request by ITC at its eighty-third session to provide detailed information of ForFITS implementation at the eighty-fourth session of ITC.

Since 2015, ForFITS has been regularly used for both internal and external applications, demonstrating the tool is appropriate and accurate to provide energy demand and associated CO_2 emissions for the transport sector at the national and sub-national levels.

Contents

I. Background

1. The ECE Sustainable Transport Division developed the For Future Inland Transport Systems (ForFITS) model from 2011 to early 2014 in the framework of a United Nations Development Account (UNDA) seventh tranche project. The ECE Inland Transport Committee (ITC) endorsed the tool and encouraged governments to use it. The ForFITS model aims at assessing energy use and CO_2 emissions and evaluating the impacts of policies intended to mitigate such emissions. ForFITS covers all transport modes with an emphasis on inland modes (road, rail, inland navigation).

2. ForFITS analysis takes into account among other things information about vehicle classes, powertrain technologies and fuel blends. ForFITS projects future transport activity, energy use and CO_2 emissions as a result of the evolution of socioeconomic parameters (Gross Domestic Product (GDP) and population), cost of driving, structure of the transport system and technology deployment. This means that the model with its "policy converter" approach is able to evaluate a large number of policy measures, such as modal shift from private vehicles to public transport, fuel taxation schemes, subsides to cleaner vehicle technologies and introduction of biofuels, under different potential scenarios (assuming a certain growth of GDP, population, oil price).

3. These policy interventions and scenarios are defined by the model user through specific inputs. The ForFITS decision support tool has been designed to provide key insights about the impact of future transport demand on energy and emissions; it is of particular relevance to developed countries with high quality data available, as well as for developing countries with limited data and information. This way, as it gains broader use, it can lead to globally comparable results and thus policy dialogue at a global level. ForFITS review results can also be valuable inputs in the review mechanisms of the Sustainable Development Goals monitoring.

4. At its eighty-third session, ITC requested the secretariat to provide detailed information of ForFITS implementation at the eighty-fourth session of ITC (ECE/TRANS/304, para. 47), subject of this report.

II. Use of ForFITS and its implementation over time

A. Implementation of ForFITS since its finalization

5. The development of ForFITS was a three-year activity started in 2011 with the goal of enhancing international cooperation and planning towards sustainable transport policies, with a particular aim of facilitating climate change mitigation. The project was funded by UNDA seventh tranche and it involved all United Nations Regional Commissions. The project included five capacity-building workshops in each of the Regional Commissions to give hands-on opportunity to learn and use the tool. A summary of each training session that took place in the course of 2013, with the material used, and participants, is available on the ForFITS webpage.[1]

6. ForFITS was aimed to be used by two main audience categories:

(a) Internally with the United Nations Secretariat to provide in-house analysis on transport, energy and greenhouse gas emissions in the decades to come;

(b) To be used freely by any interested parties as ForFITS and all its related documentation are freely available online.[2]

1. Internal applications

7. Track record of the use of ForFITS within ECE showed the model has been regularly used within and cross ECE divisions for various projects. This section briefly summarizes

[1] https://unece.org/forfits-model-assessing-future-co2-emissions?accordion=3

[2] https://unece.org/forfits-model-assessing-future-co2-emissions

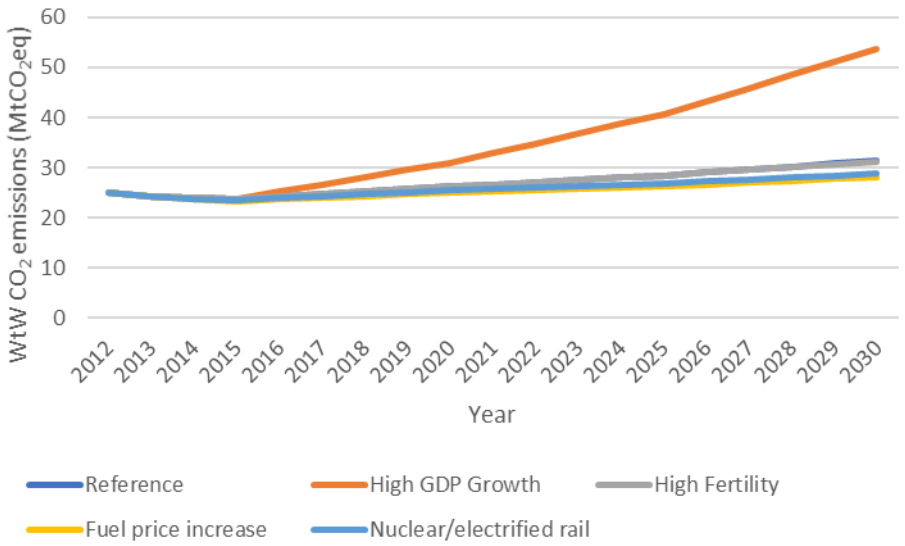
the work done and results achieved, synthetized in a few sentences by application type and chronological order. Only the activities occurring after the UNDA funding expired are shown below. Activities occurred under the UNDA funding can be found in the ForFITS webpage.[1]

8. From 2015, internal ForFITS activities have started in close collaboration with the ECE Environment Division as part of Environment Performance Reviews (EPRs). The close collaboration with the Environment Division of ECE is recurrent with four ForFITS analysis done until 2020, and more expected in the future.

(a) 2015: Belarus EPR

9. The first country where a ForFITS EPR analysis had been applied was Belarus in 2015. Main outcomes include various scenarios projecting energy use and CO_2 emissions to 2030, with emissions growth under all scenarios from the 2015 base year (Figure 1).

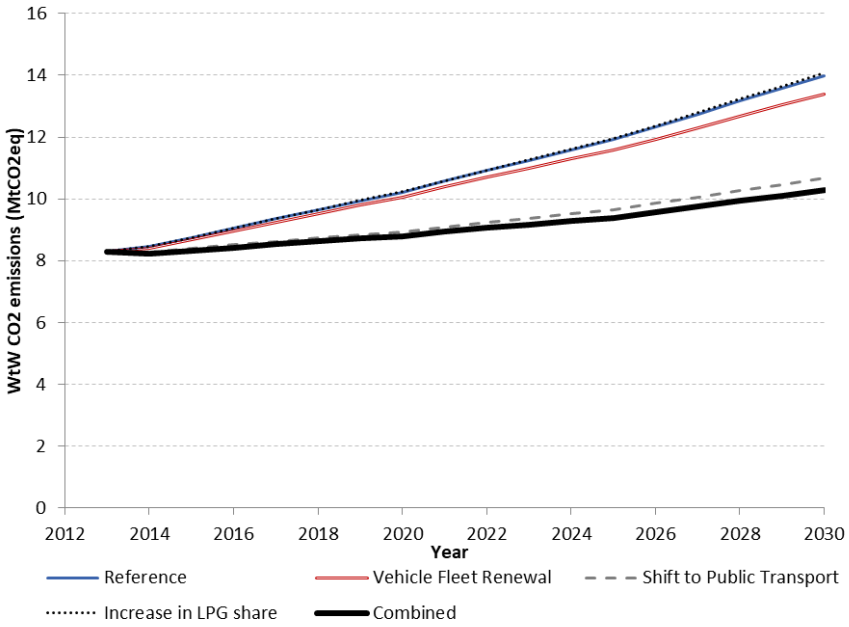
Figure 1
Belarus Projected Well-To-Wheel CO_2 emissions for transport under various scenarios, 2012-2030



(b) 2016: Tajikistan EPR

10. Another EPR ForFITS activity took place in 2016 in Tajikistan. Different scenarios were developed showing the mitigation potential of policies on fleet renewal, mode shifting and fuel shifting, together with a scenario combining all the three actions together. With the assumption taken for the analysis, the modal shifting to public transport offered the largest potential to reduce the growth in CO_2 emissions until 2030 (Figure 2).

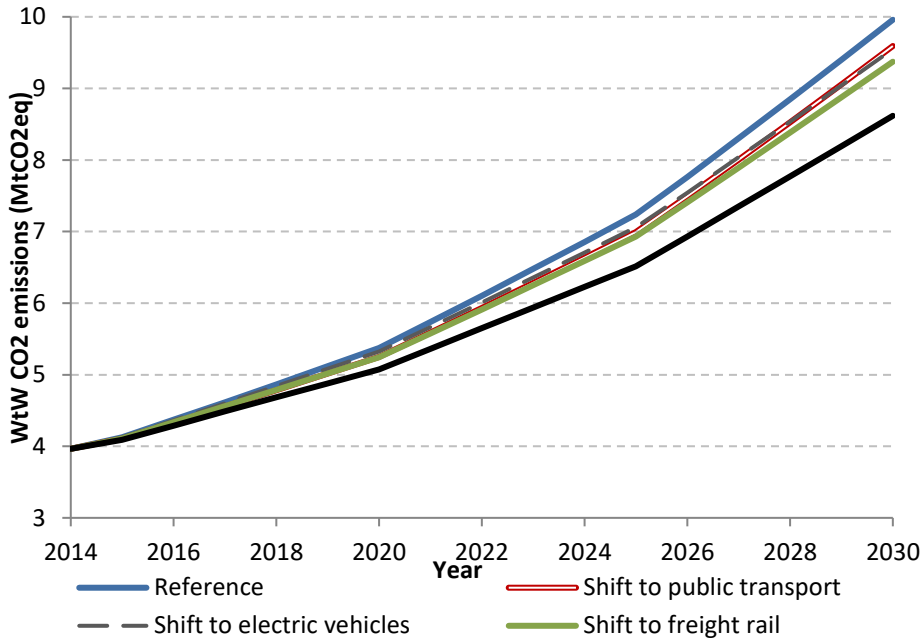
Figure 2
Tajikistan projected Well-To-Wheel CO_2 emissions for transport under various scenarios, 2013-2030



(c) 2017: Albania EPR

11. The following year, in 2017, a ForFITS analysis has been performed for Albania. The projection using ForFITS showed that a strong rise in CO_2 emissions was expected in the country by 2030, regardless of the actions and policies taken to mitigate them (Figure 3). Combining all the measures analysed, a reduction of about 15 per cent from the 2030 baseline was expected, with actions deployed to increase the share of freight rail transport, public transport and electrified vehicles.

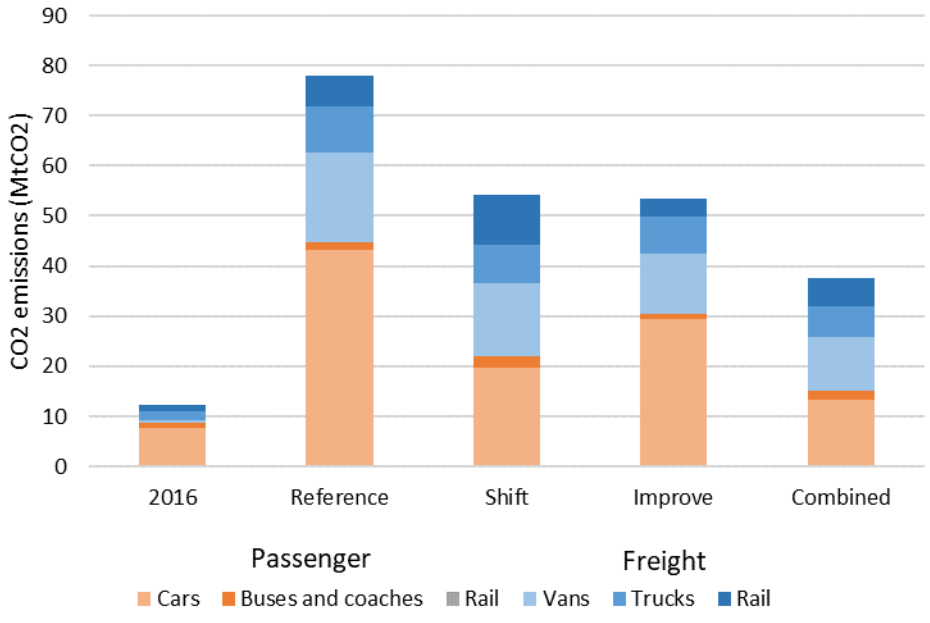
Figure 3
Albania projected Well-To-Wheel CO_2 emissions for transport under various scenarios, 2014-2030



(d) 2019: Uzbekistan EPR

12. In 2019, a new edition of the EPR of Uzbekistan also included a ForFITS analysis, where the time horizon was extended to 2045, and where scenario where classified according to the Avoid/Shift/Improve approach to sustainable mobility, focusing on the Shift and Improve components that are more appropriate for ForFITS analysis. With ambitious policies and technology deployments, the expected growth in CO_2 emissions from 2016 to 2045 can be cut by half in the country (Figure 4).

Figure 4
Uzbekistan projected Well-To-Wheel CO_2 emissions for transport under various scenarios, 2016-2045



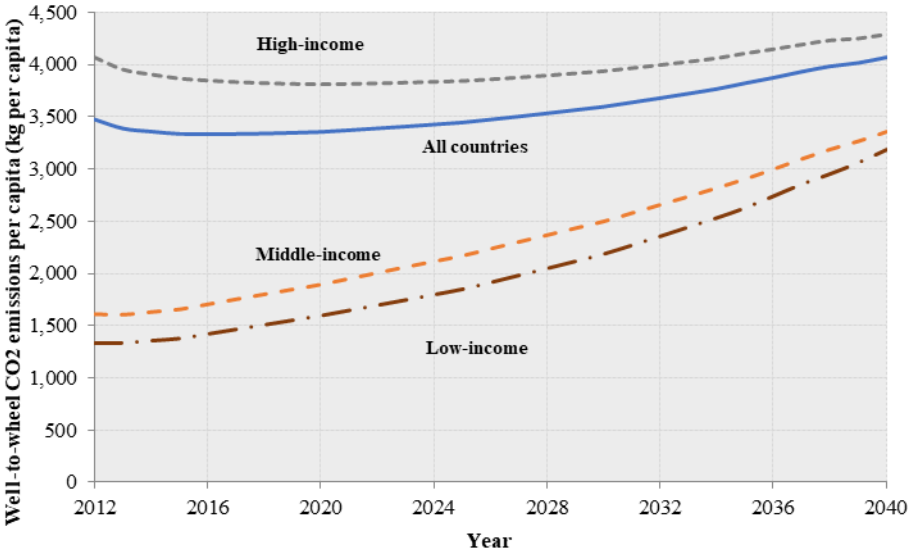
(e) 2016: ECE study

13. For the seventy-eightth session of ITC, the secretariat prepared a study for the whole ECE region (Informal document ITC (2016) No.13) to showcase and provide a useful basis for analysis of region-wide trends in vehicle activity, energy use, and CO_2 emissions stemming from the transport sector for ECE member States. This activity involved data collection necessary to run ForFITS for each ECE Member State for the 2012-2040 time period.

14. This data collection exercise demonstrated not all ECE Members States had the data available to make ForFITS run, and that some metrics such as average annual distance or average fuel economy of vehicle fleets was not widely available.

15. The analysis consisted of only baseline projections, with no alternative scenarios, showed that CO_2 emissions were expected to rise significantly in low- and middle-income ECE countries with their per capita emissions getting closer to high income countries (Figure 5).

Figure 5
Well-to-wheel CO_2 emissions per capita from inland transport, by income level, in selected ECE member States: 2012–2040



(f) 2016: Non-Road Mobile Machinery feasibility study

16. In 2016, a feasibility study had been performed to assess the possibility of including Non-Road Mobile Machinery (NRMM) into ForFITS. After careful analysis of data availability, modelling approaches and compatibility with the ForFITS modelling architecture, the study concluded that NRMM could be integrated into ForFITS, pending further availability of funds (Table 1).

Table 1
Feasibility of NRMM modelling concepts for a ForFITS module

Sector	*Agriculture*	*Forestry*	*Construction*	*Mining*
Data availability and quality	Good	Weak	Fair	Weak
Correlation using economic indicators	Good	Weak	Weak	Weak
Correlation using non-economic indicators	Good	Good	Good	Good
Generic modelling approach compatibility	Yes, 2 options to be investigated	No, simplified approach proposed	To be confirmed for economic data correlation, using machine sales instead of stock	Yes, activity projections to be refined
User inputs	Sectorial GDP, cultivated area, (Crop production)	Roundwood production	Sectorial GDP, Construction of paved road	Sectorial GDP, Extracted material (mass), Mining system status, per cent open pit / underground mines
Overall rating	Ready for modelling; Two options to be investigated in more detail for the best fit for the model	Simplified approach ready to be modelled. Further research required to be compatible with generic modelling approach	Analysis relying primarily on machine sales, economic indicators correlation weak	More analysis required to refine both economic and non-economic correlation

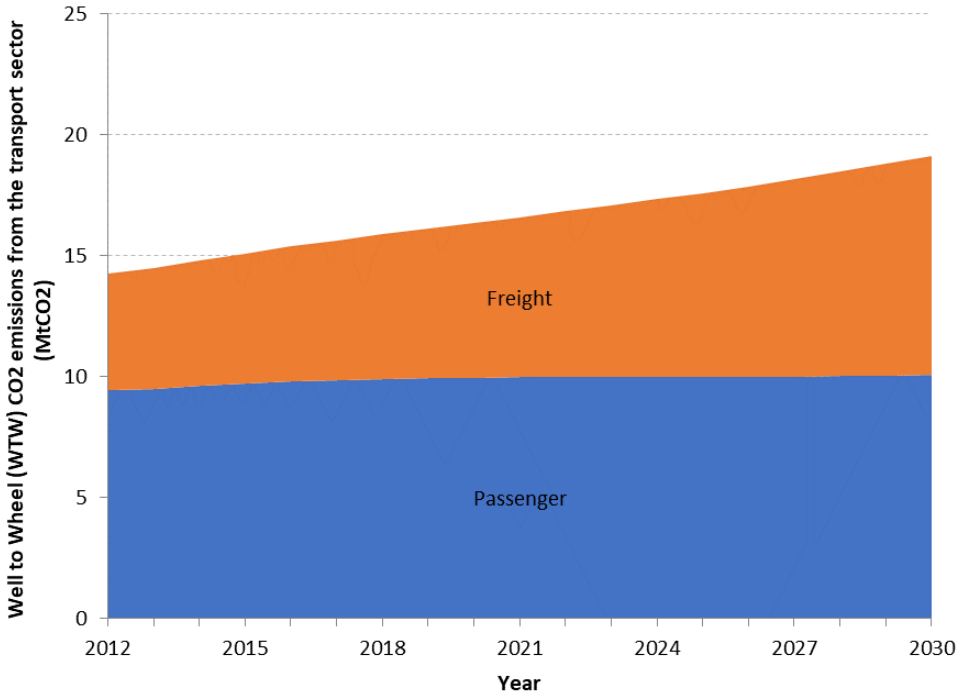
Weak	Data and correlation is non-existent or weak; sector not ready for generic modelling approach
Fair	Some data and/or correlation found; a model could be done but further analysis desirable to back the initial findings
Good	Satisfactory data and correlation to build a model framework that could be improved in the future with more data and user's feedback
Very good	High quality data and correlation lead to robust linkages to develop a strong modelling approach

(g) 2015: THE PEP Lithuania and Kaunas

17. In the framework of the Transport, Health and Environment Pan-European Programme (THE PEP), several activities have been done focusing on ForFITS modelling at the urban level. In 2014/2015, a joint work had been performed both at the country and city scales in Lithuania and Kaunas, as part of THE PEP relay race that took place in Kaunas.[3]

18. At the country scale, passenger transport CO_2 emissions were expected to stabilize whereas freight CO_2 emissions would increase substantially in the baseline scenario (Figure 6). The analysis studied the impact of several mitigation strategies on both passenger and freight, with a change in transport habits through higher environmental consciousness to have the highest impact with the assumptions used.

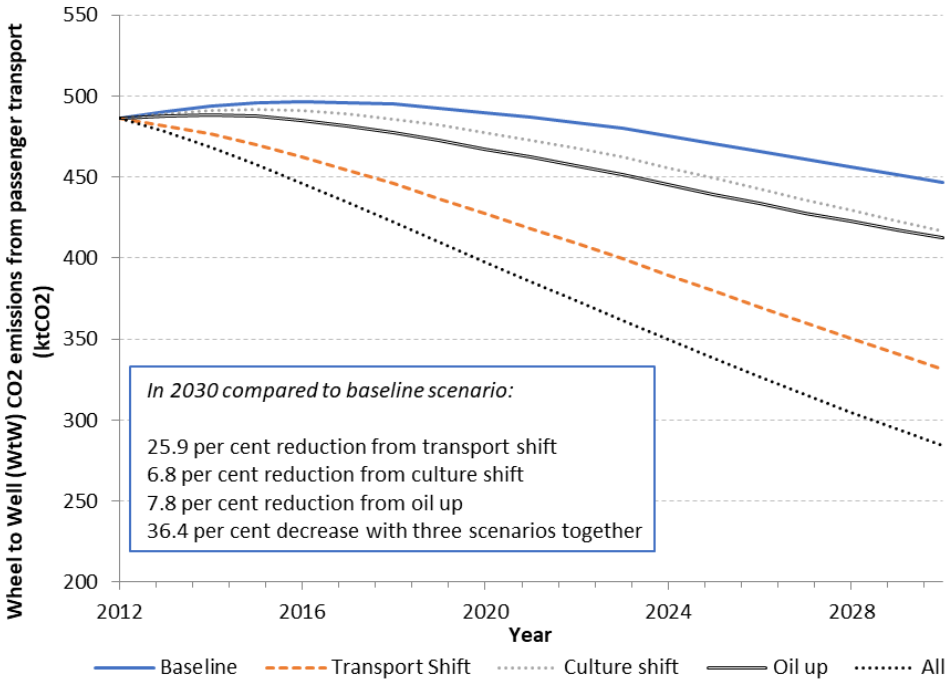
Figure 6
Projected Lithuania Well-To-Wheel (WTW) CO_2 emissions from the transport sector under baseline scenario, 2012-2030



19. For the city of Kaunas, similar simulations were performed at the scale of the city area. The potential for mode shift to public transport had shown the highest potential for CO_2 emissions reduction with approximately 20per cent CO_2 emissions reduction potential in 2030, compared with the baseline projections (Figure 7).

[3] https://thepep.unece.org/node/136

Figure 7
Kaunas city Well to Wheell (WtW) CO_2 emissions from passenger transport under different scenarios



20. Further ForFITS activities had been delivered as part of the Carbon neutrality project of the Sustainable Energy Division,[4] where expertise had been shared on future technologies and forthcoming policies emissions reduction potential was shared among the stakeholders participating to the project.

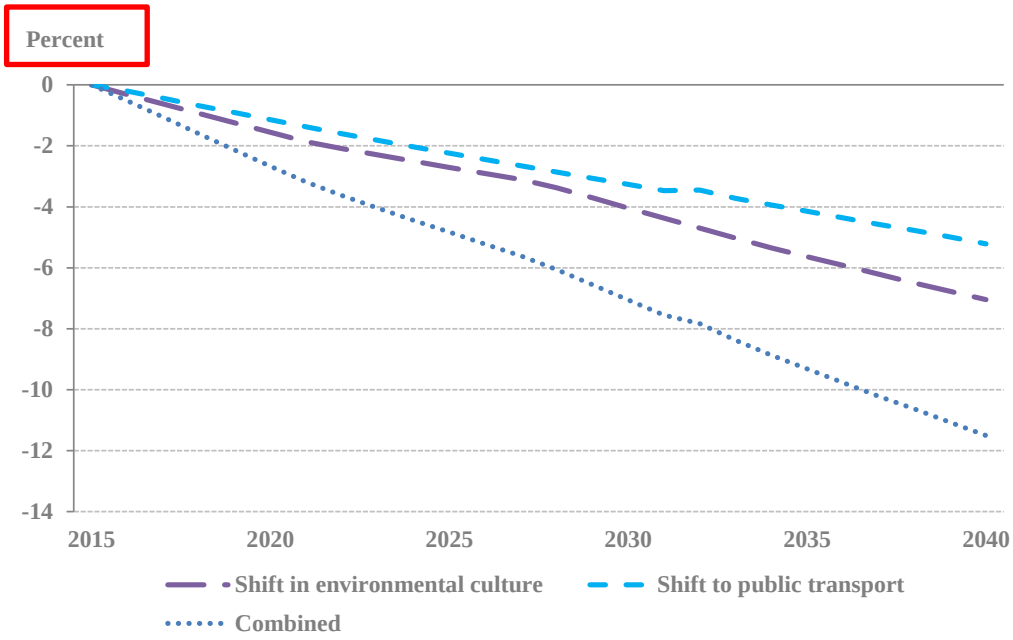
(h) 2015: THE PEP Mannheim

21. Other ForFITS runs were performed at the metropolitan area level in Mannheim in 2017, as part of THE PEP activities. ForFITS scenarios analysis showed potential to reduce CO_2 emissions from passenger transport by around 12per cent between 2015 and 2040, mainly through avoid and shift actions, by better mobility demand management and shift to lower carbon transport modes (Figure 8).

[4] A brief introduction to the carbon neutrality project is available at: https://unece.org/sites/default/files/2021-04/Ms%20Iva%20Brkic.%20Pathways%20to%20Sustainable%20Energy%20%26%20Carbon%20Neutrality%20Project.pdf

Figure 8

Projected percentage decrease in Well-To-Wheel CO_2 emissions in Mannheim for transport under various scenarios compared to the reference scenario, 2015-2040



2. External use

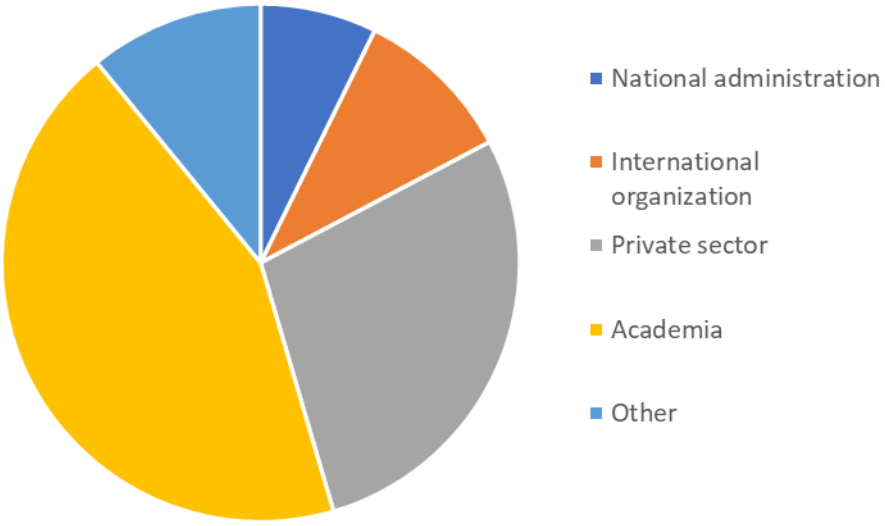
22. ForFITS was designed and deployed as a publicly available tool, so that any party willing to perform simulations about future CO_2 emissions of the transport sector were able to do so.

23. Since its release in 2014, there has been no tracking of the number of downloads of ForFITS to track its use and applications by all kind of stakeholders. Nevertheless, since 2019, a questionnaire has been added prior to accessing the link to download ForFITS freely.

24. To date, more than 100 persons/institutions have filled the questionnaire to download ForFITS since 2019. Basic questions from the survey showed that most interested parties are coming from academia, following by the private sector, representing more than 70per cent of ForFITS downloads (Figure 9).

Figure 9

Type of institutions downloading ForFITS, 2019-2021



25. Looking at the gender dimension, Persons who downloaded ForFITS were 60per cent male versus 40per cent female, and the tool had been downloaded all over the world in more than 40 different countries over all continents, showing the global nature of the tool.

26. The ECE secretariat had been aware of some external applications of ForFITS that was not done by the ECE secretariat, and where in some cases support was sought from the ECE secretariat.

27. For example, a ForFITS evaluation of the city of Lyon in France was performed as part of a master thesis in 2014. More recently, a ECE-funded project in Kazakhstan required ForFITS analysis to evaluate the impact of car sharing and car pooling on CO_2 emissions.

B. Funding requests to improve the resources of ForFITS

28. In order to further develop ForFITS (see chapter IV), several funding requests have been undertaken, both towards external institutions for extrabudgetary activities, and as part of the UN regular budget activities. Several potential sources of funding have been explored in to order to expand ForFITS (Table 2).

Table 2
Funds request for ForFITS activities

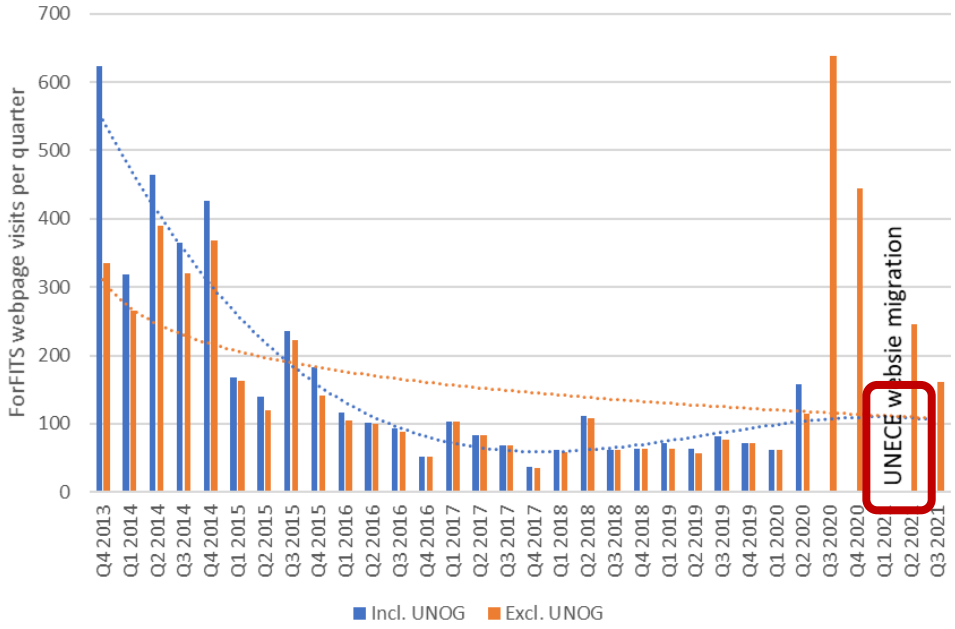
Funding type	*Funding institution*	*type of activity*	*Request date*	*Amount*	*Outcome*
External	Ministry of Environment, Canada	feasibility study to include NRMM in ForFITS	Nov-14	90 000 $Can	Report delivered
Internal	ECE Environment Division	Data collection for Environment Performance Review in Tajikistan	Jun-15	2 500 USD	Funds granted
Internal	ECE Environment Division	Data collection for Environment Performance Review in Belarus	Jun-15	6 700 USD	Funds granted
Internal	ECE Environment Division	Data collection for Environment Performance Review in Albania	Oct-16	3 500 USD	Funds granted
External	ITF (International Transport Forum)	Decarbonizing Transport Project deliverable	Apr-18	30 000 USD	no agreement reached
Internal	ECE Environment Division	Data collection for Environment Performance Review in Uzbekistan	Jan-19	3 500 USD	Funds granted
External	GIZ (German develomment aid)	Develop Handbook of Emissions Factors (HBEFA) World database	Mar-19	50 000 USD	Project has not materialized
Internal	UNDA - 12th Tranche	develop ForFITS for city application	Aug-19	30 000 USD	No money reached ForFITS team
External	WEF (World Economic Forum)	lifecycle of vehicles	Nov-19	50 000 USD	no agreement reached
External	ADB (Asian Development Bank)	Asian Transport Outlook insights	May-20	20 000 USD	no agreement reached
Internal	United Nations regular Budget	ForFITS improvements	Mar-21	10 000 USD	To be decided end 2021
External	WBCSD (World Business Council on Sustainable Development)	Cost of EV fleet recharge, taking vehicle, battery, energy and real estate expenditure into account	Apr-21	40 000 USD	still under discussion

Funding type	*Funding institution*	*type of activity*	*Request date*	*Amount*	*Outcome*
Internal	ECE Environment Division	Data collection for Environment Performance Review in Azerbaijan	Nov-21	6 000 USD	Funds granted

C. On-line presence and visibility

29. The ForFITS webpage was launched in the course of 2013, with all resources and documentation available in the last quarter of 2013. Since then, the visits of the ForFITS-webpages and files has continuously decreased (Figure 10), to stabilize from 2016 onwards, with a peak during the recent lockdowns.

Figure 10
Number of page views of ForFITS webpages, including and excluding UNOG computers, 2013-2021



30. The initial audience during the UNDA funding that stopped at the end of 2014 decrease a lower level that seemed to stabilize for the last few years. Since 2019, a survey has now been added for people willing to download the model to collect basic information of the model user profile on a voluntary basis (Chapter II.A.2.).

31. The SLoCaT initiative has compiled the transport Greenhouse Gas (GHG) tools available globally from different stakeholders, showing that there are more than 150 transport GHG tools available[5], with many of those being able to perform similar tasks to project emissions forward in the future, as is ForFITS.

32. An evaluation report held in 2018/2019[6] made several recommendations for the future of ForFITS; Recommendation 1 " Revisit the desired roles of ForFITS within the purview of ECE and define its targeted users" is of particular importance and this document explores potential routes to address this Recommendation 1 (chapter IV), with or without additional resources.

[5] http://www.slocat.net/news/1452

[6] https://unece.org/DAM/OPEN_ECE/03_Evaluation_and_Audit/Evaluation_Reports-with_SPs/02-Transport/Forfits_Review_Final_report_25.02.2019.pdf

D. ForFITS outreach

33. In recent years, the ECE secretariat had been approached to join forces in the transport and energy models arena, which could be a way to better promote ForFITS and find synergies between modelling teams to develop more robust forward-looking models.

34. Since 2018, ForFITS has joined the International Transport Energy Modeling partnership (iTEM),[7] gathering people and organizations interested in the role of energy in the world's transport system. iTEM regularly runs model intercomparison projects (MIPs) to assess the robustness of various modelling frameworks, and also considered the development of an open database of historical transport statistics for baseline calibration of models, through a transparent, scientific process.

35. ForFITS has also been invited to join the Energy Demand changes Induced by Technological and Social innovations (EDITS) network.[8] The EDITS network brings together experts of various disciplines to regularly discuss about and engage in the multi-faceted energy demand research. The EDITS community works together based on common interest in interlinked topics, on transferring methodological knowledge, and on exploring modelling innovations across demand-side models.

36. In the course of 2020/2021, ForFITS has become an Intergovernmental Panel on Climate Change (IPCC) registered model for the inception of the Assessment Report 6 (AR6). Registered models can submit modelled data to be considered by IPCC transport chapter authors when analysing forthcoming emissions from the transport sector. Given the lack of global model runs by ForFITS, no dataset could have been submitted.

37. ForFITS has been invited to join the International Energy Agency (IEA) Mobility Model (MoMo) partnership as a research partner. Legal discussions were still ongoing when this paper was written.

III. ForFITS validation run

38. In order to show ForFITS modelling capabilities, a validation run of ForFITS has been performed internally by the secretariat in 2018/2019 using modelled data to be compared with real data. The validation run consists of comparing ForFITS projections under various scenarios and real data that has been collected over a similar time period.

39. For this exercise performed in 2019, Hungary has been chosen as input data for ForFITS were readily available as a ForFITS analysis had been performed in Hungary during the development of the tool in 2013/2014. Transport and energy use statistics have been collected by the Working Party on Transport Statistics of the Sustainable Transport Division of ECE (WP.6) for vehicle fleet, vehicle specifications and traffic activity[9]. Energy use statistics have been extracted from the International Energy Agency (IEA) World Energy Balances.[10]

A. ForFITS data and scenarios

40. The base year for ForFITS projections is 2010, and economic parameters (GDP) are the main driver for traffic activity projections. ForFITS includes all modes of transports, whether inland, aviation or maritime.

41. As part of the projections, several scenarios were included for the projection to 2040:

(a) Scenario A: reference scenario with existing trends, mode choice and energy mix prolonged to 2040, based on predetermined growth of GDP per capita;

[7] https://transportenergy.org/

[8] https://iiasa.ac.at/web/home/research/researchPrograms/Energy/Research/EDITS/EDITS.html

[9] ECE Statistical Database, https://w3.unece.org/PXWeb/en

[10] IEA Data Services, http://wds.iea.org/WDS/Common/Login/login.aspx

(b) Scenario B: high energy price scenario with a doubling of oil prices between 2010 and 2040;

(c) Scenario C: High mode share towards public transport due to higher energy prices as stated in Scenario B;

(d) Scenario D: This step is focusing on the introduction of advanced transport technologies due to the increase in oil prices and the effect of modal shift (Scenario C);

(e) Scenario E: it introduces biofuel mandates reaching 20per cent by 2040 on top of all the assumptions from scenario D.

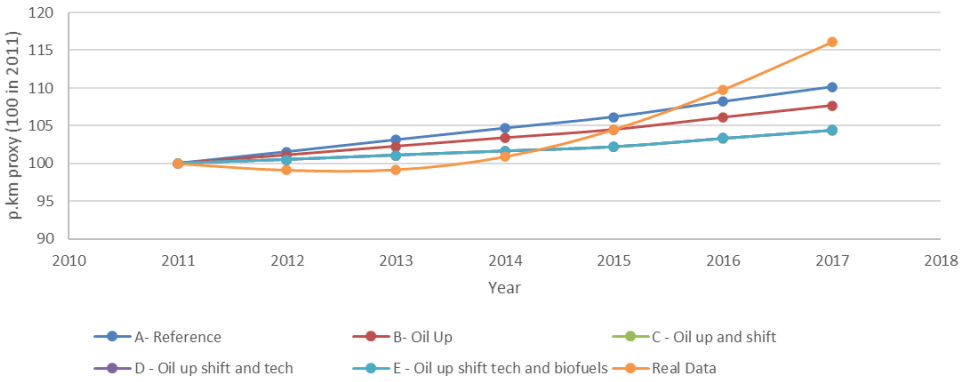
42. Even though ForFITS projections have a time horizon to 2040, the comparison focuses on the 2010 to 2017 time period, where both modelled data and real data are available.

B. Traffic data comparison

43. ECE collects statistics for inland transport, when ForFITS covers all modes, including aviation and maritime. To be able to compare traffic activity numbers, an index has been used, with an index of 100 calculated in 2010 (or 2011 in the case of p.km as there was no data available in 2010 in ECE database), baseline year for the ForFITS runs. This way, the evolution from 2010 (or 2011) to 2017 can be compared between ECE statistics and ForFITS runs.

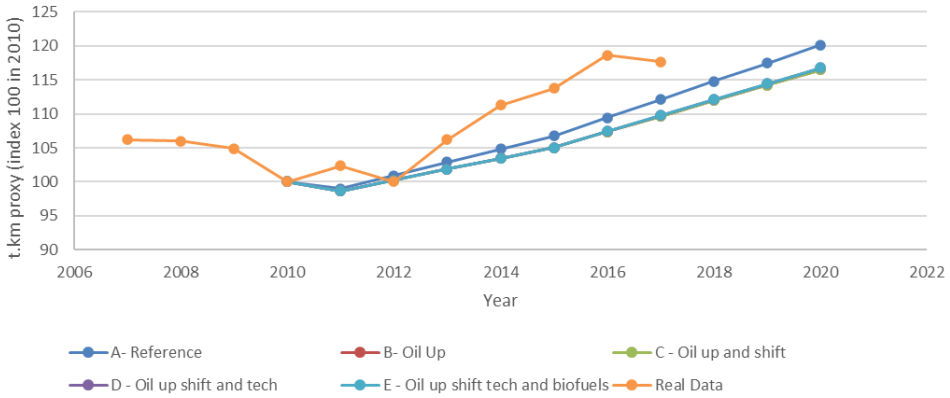
44. Passenger activity has been overestimated by ForFITS in the 2011-2014 time period and underestimated in the years 2016-2017 (Figure 11**Error! Reference source not found.**). The model did not seem able to capture the stagnation/ slight decrease of activity before a rapid growth in the latest years of data available, under all scenario modelled.

Figure 11
Passenger.kilometre evolution in the 2011-2017 time period



45. Freight movements also appeared to have grown faster than expected by the model, even in the reference scenario that is the scenarios that is the closest to what happened in the last few years (Figure 12).

Figure 12
Passenger.kilometer evolution in the 2011-2017 time period

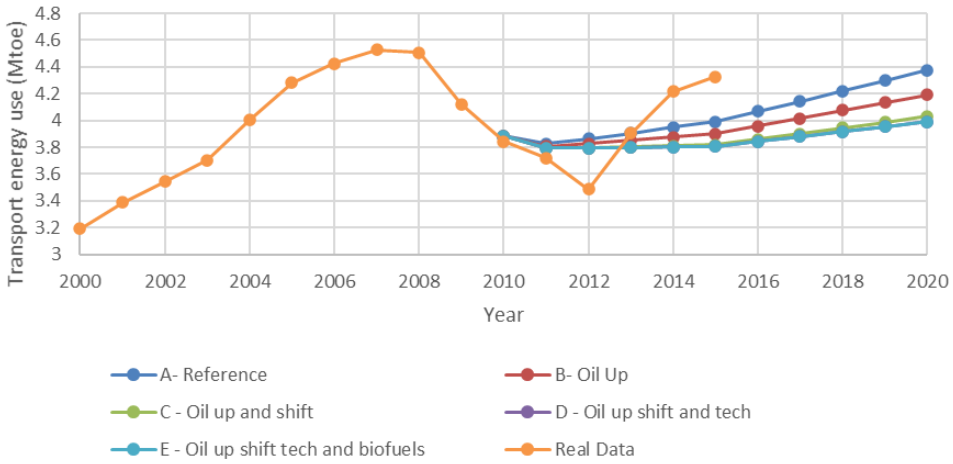


C. Energy use data comparison

46. The IEA data collected from official sources does include all modes of transport and can therefore be directly compared. The 2010 baseline value matches accurately the statistical evidence, showing that the model has been properly calibrated for that base year.

47. In the years for which both real and modelled data are available, ForFITS is not capable of modelling ups and downs as it occurred in reality, and so struggled to match real data in all scenarios considered. The higher scenario for energy use significantly underestimated the energy use in 2015 by about 8per cent (Figure 13), indicating that the country has chosen an unexpected path towards high energy use from the transport sector.

Figure 13
Energy use evolution in the 2000-2020 time period



D. Validation run conclusion

48. The validation run on ForFITS performed for Hungary highlights the challenges that long-term models are facing when matching real life evolution. Such models, usually being based on exogenous parameters projections, such as GDP, are not designed to forecast crises or temporary peaks.

49. ForFITS trends should be looked at over the long term. The assumptions used for the reference can nevertheless be questioned and could deserve further analysis, as they seem to have underestimated reality by a significant amount in the 2010-2017 time period.

50. Alternative scenarios, all designed to show low carbon pathways, and the potential for policies and economic levers to decarbonize the transport sector in Hungary, did not seem to materialize in reality.

51. Crisis, such as the one occurred in 2020/2021 with COVID-19 are impossible to predict but have a deep impact on short- and medium-term projections.

IV. Next steps: Model developments strategies

52. To make ForFITS appealing to a wider audience and in order to increase its attractiveness compared with other similar tools developed by other institutions, several areas of potential improvements have been identified, where the model would need to be further developed to provide accurate and state of the art results.

53. ForFITS has been lacking resources since the UNDA funding stopped, especially for the model upgrade and development. The ECE secretariat resources dedicated to ForFITS (about 0.4 person.year, half of that in the last few years due to staff shortages) had been mainly utilized for internal applications within the ECE secretariat (See chapter II.A.1.).

54. In comparison with other modelling groups active in the transport and energy field, ForFITS probably has one of the smallest resources. Under such constraints, adding value remain challenging, and it is therefore advised to develop close working relationship with other modelling groups in order to maximize the resources and the added value, by building stronger modelling frameworks among all the stakeholders involved rather than competing models.

55. The ECE secretariat would advise to consider a two-way path: (a) carry on with an expert-level ForFITS model, using the existing ForFITS model and resources (labelled ForFITS 1.0 herein), with a lot of details and more in-depth knowledge of modelling necessary to be able to perform model runs; and (b) if more resources became available, then a more accessible web-based tool with a broad list of policies and their estimated impact on GHG and air pollution (ForFITS 2.0 herein) could be developed as originally aimed at the early stage of the UNDA contract deployment (See para. 0).

56. ForFITS 1.0 and ForFITS 2.0 would be two separate, but harmonized products that would have different architectures, modelling framework and user interfaces; ForFITS 1.0 would be used internally by ECE staff and trained users while ForFITS 2.0 would be user-friendly and easy for everyone to be used.

57. Using the limited resources available, the ForFITS 1.0 activity stream would focus the existing resources on internal use of the tool and to develop specific and targeted relationships with other bodies where ForFITS add value. Additional ForFITS 1.0 modules on topic where added value for other modelling frameworks could also be developed pending additional resources (chapters IV.B.2. to IV.B.6).

58. For example, as part of ForFITS 1.0 activities, a ForFITS module on “Real-time monitoring of EV recharge emissions” is under development, following a joint workshop on the topic held together with the Sustainable Energy Division of ECE[11] (as part of the activities detailed in chapter IV.B.3.).

59. To get additional resources to develop ForFITS 2.0, the UN Road Safety Fund might offer funding opportunities as some donors expressed the wish to have road safety and environmental impacts assessed as part of the UNRSF activities.[12]

[11] https://unece.org/sustainable-energy/events/online-workshop-real-time-upstream-emissions-electric-vehicles-during

[12] http://sdg.iisd.org/commentary/guest-articles/saving-young-lives-protecting-the-planet-and-growing-the-economy-road-safety-for-2030/

A. ForFITS 1.0 revisited roles and audience

60. The proposed ForFITS 1.0 strategy consists in continuing the existing internal analysis under request for other sections, other divisions. ForFITS through the ECE secretariat has been continuously collaborating with ECE's Environment Division, THE PEP to provide analytical work for specific projects.

61. To date, such activities have been linked with specific data collection efforts held by local consultants where the model is to be applied, also benefiting the transport statistics of the Sustainable Transport division.

62. Additional activities as part of ForFITS 1.0 would be to add interactive /static digital infographics together with the analysis performed: Following the assessment of data visualization tools, it would be suggested to add some interactive infographics going together with written reports to come along with the internal analysis done, in case reports (such as EPR, THE PEP,…) have an online component where the ForFITS material could be published. Some prototypes infographics had been developed[13] using the Tableau software and could potentially be deployed as part of ForFITS 1.0 activities.

63. A important pillar of ForFITS 1.0 strategy would be to consider linkages with other publicly available transport and energy models: Several other models are offering features that ForFITS does not have; for example, the MobilizeYourCity initiative has just launched a city-level tool to quantify GHG and air pollutant emissions from the transport sector, that could be complimentary to ForFITS to some regards, such as air pollution, or city-level modelling.

64. Other models could also benefit the scope and accuracy of ForFITS outputs that will be investigated as needs occur. The models to be considered under the inter linakges between model includes, but is not limited to ITF's Decarbonizing Transport Initiative, WBCSD SiMPlify, MobilizeYourCity GHG calculator, iTEM network, and the IEA's Mobility Model (with whom potential collaboration is being considered, see para. 0).

65. As part of the reach out activities already held in the recent past (See chapter II.D.), ForFITS 1.0 would continue with such activities to mutualize resources with other modelling groups, so synergies can be found and ForFITS could add value where most beneficial with model users and the wider modelling community.

B. ForFITS potential model improvements

1. ForFITS 2.0: User Friendly model separated from ForFITS 1.0

66. To further improve the model, a migration of ForFITS into an easier, user-friendly and simplified tool could be developed as ForFITS 2.0 that would have a different audience targeted at the initial ForFITS concept to " Develop a user-friendly, web-based application toolkit"[14] that includes a "policy converter tool".[15]

67. During its development in the 2012/2014 timeframe, ForFITS has been based on the Vensim software, for its modelling interface allowing to follow the calculations more easily than by tracking Excel formulas. The numerous interactions and calculations introduced in ForFITS made it difficult to use without extensive training and significant resources, despite the exhaustive material available online.

68. The original UNDA documentation[16] from which ForFITS was developed and funded, were aiming at:

[13] https://public.tableau.com/app/profile/francis5510/viz/PieBar/PieBar

[14] UNGA, Proposed programme budget for the biennium 2010-2011, A/64/6 (Sect.35)

[15] Project documents for the 7th tranche of the Development Account, https://www.unece.org/fileadmin/DAM/trans/doc/themes/ForFITS/UNDA_Project_Document_CO2.pdf

[16] proposed 2010-2011 programme budget (A/64/6 (Sect.19)), Part V, Section 19 "Economic development in Europe", particularly subprogramme 2, "Transport"

"(a) Review and analysis of existing assessment models for the evaluation of transport activities, energy consumption and CO_2 emissions, and development of a standard methodology;

(b) Implementation, validation and benchmarking of a standard CO_2 assessment tool;

(c) Development and testing of a user-friendly, web-based application toolkit;

(d) Preparation of region-specific capacity-building and training materials in all official languages. In this respect, one city per region would have to make a detailed assessment and capacity-building effort;

(e) Preparation and conduct of capacity-building and training workshops for government policymakers and industry stakeholders to raise awareness and provide skills for the use of the standard CO_2 toolkit."

69. Given time and budget constraint, not all objectives had been met at the end of the funding cycle and user friendliness and web-based applications have been undervalued for the final version of ForFITS.

70. Such ForFITS 2.0 would have a simpler interface and calculation methodology purely based on transport measures and its impact on GHG and air pollution. ITF's "Transport Climate Action Directory"[17] could be used as a basis for the tool's policy converter tools and its estimated impacts. More detailed timeline and budget for ForFITS 2.0 can be found in Annex I.

2. Adding Air pollution into ForFITS 1.0

71. Air quality is a growing environmental concern for many citizens, and despite past improvements the transport sector remains a significant polluter, particularly in cities. The World Health Organization recently strengthened Global Air Quality Guidelines aiming to save millions of lives from air pollution.[18]

72. ECE's Convention on Long-range Transboundary Air Pollution offers robust methodology to quantify air pollution emission from transport as part of the EMEP/EEA Air Pollutant Emission Inventory Guidebook.[19] Transport emissions inventory tools such as COPERT or HBEFA could be used as part of a ForFITS module on air pollution.

73. Adding air pollution would require adding a detailed fleet model, where granular regulatory emission levels, leading to a profound architecture upgrade of ForFITS and given the modelling constraint of the existing ForFITS underlying programming software (Vensim), a migration to a new programming language would be likely to be able to add air pollution into ForFITS, as explained in Annex II.

74. A modular approach to include air pollution in ForFITS could also be envisaged, where traffic activity is extracted from ForFITS and used in a separate module, increasing the time to run the model and provide outputs where performing ForFITS analysis (not quantified in Annex II).

3. Including circularity elements as add-on modules

75. During the sixty-ninth Commission session of ECE, member States affirmed commitments for circular and sustainable resource use and economy,[20] where ECE would act to close the circularity gap; today, less than 10per cent of the economy is circular, and the

[17] Transport Climate Action Directory, launched 2 July 2020, https://www.itf-oecd.org/transport-climate-action-directory-global-launch-event

[18] https://www.who.int/news/item/22-09-2021-new-who-global-air-quality-guidelines-aim-to-save-millions-of-lives-from-air-pollution

[19] https://www.tfeip-secretariat.org/guidebook

[20] https://unece.org/circular-economy/press/countries-step-commitments-circular-and-sustainable-resource-use-leveraging

transport sector can improve the monitoring and policies towards a more circular transport sector.

76. Together with the ECE Sustainable Energy Division, the Sustainable Transport Division has organized a workshop to assess the real-time upstream emissions of electric vehicles during recharge,[21] and the possibility to monitor such emissions to incentivize electric vehicle owners to reduce the emissions of their vehicle when the emissions from electricity generation are the lowest.

77. Life cycle emissions of transport energy and fuels are an important component of the circularity of the transport sector, and the momentum towards electric vehicles needs to be anticipated to be able to monitor and allocate electricity use to the appropriate sector, for emission inventory purposes.

78. The ECE secretariat is developing a paper to showcase the importance of the right time resolution and the potential impact of user behaviour on the emissions from electric vehicle recharge. A ForFITS add-on is also expected to be released to give the opportunity to any interested parties to assess the potential emission savings for any given electricity generation emission profiles that would be required as an input to the add-on. The paper and ForFITS add-on are expected to be released in the first quarter of 2022.

79. Vehicle manufacturing emissions are also an important component to a more comprehensive approach towards circularity in the transport sector, and specific addition to ForFITS could be envisaged to take the vehicle life cycle into account (Annex III).

4. CO_2 impacts from automated and autonomous vehicles

80. Automated and autonomous vehicles are being developed at a very fast pace around the globe. ECE is the leading global body developing regulatory framework for the mass deployment of those vehicles on the road, to ensure a safe and secure introduction of the related technologies on the road.

81. Studies about the environmental and climate impacts of such technologies are scarce, and the ones published often show that the data needs to power automated and autonomous systems are significant, energy-intensive and should be carefully looked at..[22]

82. Automated and autonomous vehicles are also expected to drastically change the way people move around, and potential significant rebound effects if travel times or travel comfort are altered by those technologies. Today there is a broad array of possibilities and a high degree of uncertainty to the benefits and drawbacks of those technologies.[23]

83. A feasibility study to assess the possibility to develop a modelling approach for such technologies would be an interesting first step towards looking at modelling the climate and environmental impacts of automated and autonomous vehicles (Annex IV).

5. Including Non-Road Mobile Machinery (NRMM) into ForFITS 1.0

84. The feasibility study performed in 2016 (see para. 0) showed NRMM could be added to ForFITS. Some emissions inventory experts[24] have also started to look into this, so there would be room for close collaboration on this important and often overlooked issue.

85. Taking stock of the feasibility study and the other activities occurring outside of the ECE, such implementation could occur with a reasonable budget and timeline (Annex V).

[21] https://unece.org/sustainable-energy/events/online-workshop-real-time-upstream-emissions-electric-vehicles-during

[22] https://www.emissionsanalytics.com/news/vehicle-automation-carbon-dioxide-emissions-worse

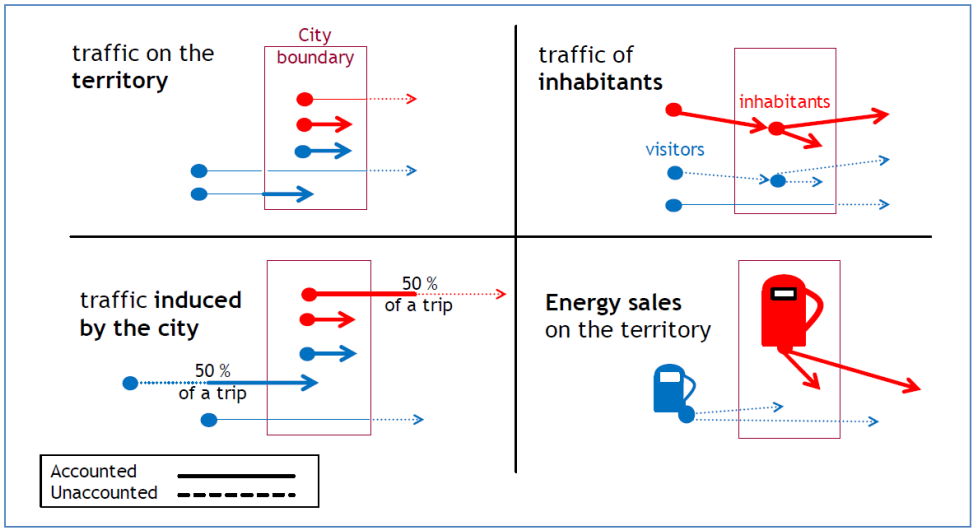
[23] Massar, M.; Reza, I.;Rahman, S.M.; Abdullah, S.M.H.;Jamal, A.; Al-Ismail, F.S. Impacts of Autonomous Vehicles on Greenhouse Gas Emissions—Positive or Negative?. Int. J. Environ. Res. Public Health 2021, 18, 5567. https://doi.org/10.3390/ijerph18115567

[24] https://ermes-group.eu/web/system/files/filedepot/19/7309a_NRMM_ERMES_2019-05-14.pdf

6. ForFITS Use in Urban cases

86. ForFITS has performed analysis of urban areas as part of THE PEP (see Chapter II.A.1.(g) and II.A.1.(h)). To perform such analysis in the most appropriate way, a territory approach is highly desirable (Figure 14), as recommended by the international initiative MobilzeYourCity.[25] As it was designed, and with its embedded modelling approach, ForFITS small scale modelling accuracy can be challenged by the fact that only the inhabitants approach can be used through the bottom-up ForFITS modelling approach adopted.

Figure 14
Possible boundaries for small scale GHG emissions inventory[25]



87. Such inhabitant approach might bring substantial bias in the transport activity data and lead to inadequate results. Other institutions, such as the International Transport Forum, have performed micro-simulations analysis to analyse the environmental impact of urban mobility in five cities, with high resources and appropriate traffic simulations models. Those limitations should be kept in mind when developing ForFITS and performing internal and/or external analysis.

88. Policies that ForFITS can handle have a national scope and have a strong economic dimension (Table 3); such policies are not always the most adequate for city level modelling, highlighting the need for further model development to properly tackle urban scale emission modelling

Table 3
Policies modelled in ForFITS

Scenarios/policies	*Baseline*	*Low*	*Medium*	*High*
3. Economic scenarios and avoid/shift policies normally implemented through economic instruments				
3.1. Changes to macroeconomic parameters (GDP and population)		✖		
3.2. Changes to fuel cost (excludes national fuel taxation schemes)		✖		
3.3. Changes to national fuel taxation schemes		✖		
3.4. Changes to purchase vehicle cost	✖			

[25] https://www.mobiliseyourcity.net/sites/default/files/2020-09/MYC%20MRV-GHG%20Guidelines%202020-Final_0.pdf

Scenarios/policies	*Baseline*	*Low*	*Medium*	*High*
3.5. Changes to road pricing			✖	
3.6. Changes to crew cost			✖	
3.7. Structural changes in freight transport due to changes in the country's economy orientation				✖
3.8. Environmental culture (participatory instruments)				✖
3.9. Changes to pipelines network extension		✖		
4. Shift policies/scenarios				
4.1. Shift from/to personal vehicles to/from public transport		✖		
4.2. Shift between large-freight modes		✖		
4.3. Changes to shares within transport modes which are grouped together in activity projections		✖		
5. Improve policies/scenarios				
5.1. Expected energy efficiency technology improvements	✖			
5.2. Penetration of new technologies (Endogenous technology choice)				✖
5.3. Penetration of new technologies (Exogenous technology choice)		✖		
5.4. Changes to fuel characteristics (Biofuels)			✖	
5.5. Vehicle fleet renewal			✖	

89. To perform accurate and representative modelling at the urban level, ForFITS would need to be further developed. For example, the International Transport Forum has been recently focusing on urban transport modelling and its impact on emissions and traffic, using network modelling that represent the city streets and vehicle flows at the individual street level.[26]

90. Dedicated timeline and budget could be developed under request.

V. Conclusions

91. Since its roll out once UNDA funding stopped, ForFITS has been regularly used for both internal and external activities, highlighting the utility and need for such tool at ECE. Limited resources at the ECE secretariat had nevertheless limited the allocation of internal resources to internal ForFITS applications rather than model developments and upgrades.

92. External use and audience of the model had been steady over the last few years, with Academia the most interested stakeholder in downloading and using ForFITS, according to the survey developed prior to ForFITS model download.

93. A two-fold strategy is being contemplated to be able to adapt to potential additional funding obtained:

[26] https://www.itf-oecd.org/itf-work-shared-mobility

(a) With no additional funding, (i) carry on with the existing ForFITS model, (ii) use digital infographics / visuals to be used with digital component of activities performed, when deployed and (ii) continue the reach out strategy to closely collaborate with other modelling groups, partnerships and activities to mutualize resources to maximise the added value of ForFITS;

(b) If additional funding is secured, develop a ForFITS 2.0 simplified model for a broader audience, develop additional features for ForFITS 1.0 on a modular approach or through a new modelling framework.

94. ITC is invited to support such approach for continuous and sustained viability of ForFITS in the long-term, recognizing the added value of ForFITS and its benefit both within and outside of ECE.

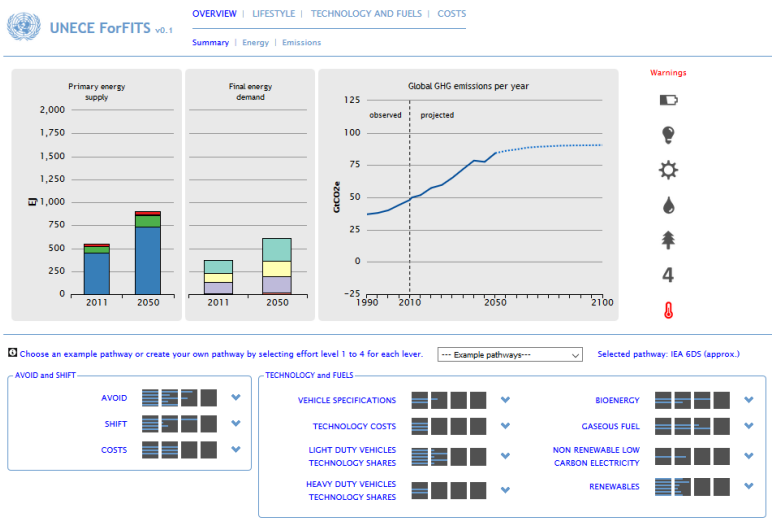
Annex I

Develop ForFITS 2.0

Project time: 36 months – Budget: 300,000 USD

ForFITS has been evaluated by external reviewers[27] to be a very efficient model that provide valuable insights into the transport sector. Yet, most users need intensive training to be able to use and disseminate ForFITS results, and to date there has been very limited use of ForFITS outside of ECE.

ForFITS visibility could be improved by developing a separate product (ForFITS 2.0) that would be aimed at the general public to show the potential for transport policies and measures to mitigate GHG emissions and air pollution from the transport sector. User definable inputs would represent the stringency of potential transport policies, with its impact on energy, CO_2 and on pollutant emissions directly updated on the output graphs and tables. This improved versatility would ease the use of the model and would benefit a wider audience. Policy makers and non-expert users would directly see the impact of policies on energy needs and emissions to better understand the challenges and embark on a more sustainable growth path of the transport sector.



Workflow

A prototype interface has already been developed during the first few months of 2016 (see screenshot above). User definable inputs are directly changed via levers to alter final impacts on energy, emissions and air pollution for the transport sector. Indicative warnings indicate if the set of policies adopted are compatible with low carbon objectives for the city, the country or set of countries that are considered. Given ForFITS 1.0 programming complexity and modelling framework (Vensim) limitations, it is suggested to develop ForFITS 2.0 using a different framework to be later coded as a web application.

Timeline and Budget

The work would 18 month for the development of the policy impact tool (in Excel of other tools) and would later require about 12 months of programming to code the tool into a web based application for the front-end. Another 6 months would be needed to make sure the results of ForFITS 1.0 and ForFITS 2.0 are comparable and consistent as well as to link with the existing back-end model results and inputs to the new visual interface. The total budget for the project would be of 300,000 US dollars from external donors.

[27] 2014 Evaluation report on ForFITS, http://tinyurl.com/j7krh9x

Annex II

Air pollution into ForFITS 1.0

Project time : 28 months – Budget: 500,000 USD

Air pollution remains a major environmental and health concern. The combustion process in internal combustion engines produces harmful emissions despite the spectacular results over the past years thanks to regulatory push and technological improvements.

Air quality is of particular concern in cities, as exposure to harmful gases is still significant all over the world. Recent evidence shows that emission reduction from light duty vehicles in real life is not as important as the regulatory limits would have indicated. This can lead to increasing lack of confidence with regard to vehicle manufacturers and regulators alike. The recent Volkswagen case has already shown it.

There is a strong need to have a better understanding of current trends in pollutant emissions from the transport sector, in order to better assess the environmental and health impacts, for example, of infrastructure investments. ForFITS aims at bringing innovative insights into the topic by using the latest emission factors available and by taking the impact of the latest regulatory developments and using them for future projection of pollutant emissions. Developing robust approaches to model pollutant emissions by each mode could help decision makers to better target their policy choices to reduction of local pollutants.

Workflow

Integrating pollutant emissions into ForFITS is an ambitious goal and developing the module for local pollutants would require significant resources. State-of-the-art expert knowledge would need to be further challenged through extensive research and consultations, including series of round tables with the best known experts. The development of the module would include its piloting out in a number of volunteering countries and cities. This part of the project would be completed by a series of capacity-building workshops in the five United Nations regions.

All material and model concepts would be made freely available.

Timeline and Budget

The overall project is expected to last for 2 years.

The total budget for the project would require 500,000 US dollars from external donors.

Annex III

Circular transport sector in ForFITS

Project time: 24 months – Budget: 400,000 USD

ForFITS is already taking fuel life cycle consideration into account to provide Well-to-Wheel CO_2 emissions. from non-transport and Non-Road Mobile Machinery (NRMM), such as agricultural tractors, construction and mining machinery are usually not taken into account in the policy choices, however, they represent a sizeable amount of GHGs.

A material module could be added to ForFITS to add the material needs to build the vehicle fleet, for the different vehicle types include in ForFITS. Adding emission factors for the carbon emission associated with each material type from existing database (such as Ecoinvent) would derive the total carbon footprint of given vehicle fleets.

To further develop the circularity module, vehicle scrappage CO_2 emissions would be added, and differentiated emission factors for recycled materials added for the user to be able to simulate the CO_2 impact of the recycled material rate.

Specific focus on alternative powertrains, and some of its specificities, such as batteries for electric vehicles, would provide deeper insight into the CO_2 impact of mass adoption of battery electric vehicles. Simulating the environmental of battery swapping versus high power recharging infrastructure might also bring some added value to forthcoming policy development.

Workflow

The ECE secretariat has initiated activities on a ForFITS add-on to simulate the impact of real -time emissions of EV recharge (para. 0) to provide further information about Well-To-Wheel CO_2 emissions for fuels.

Integrating an additional vehicle circularity feature in the existing ForFITS using Vensim might exceed the software capability, so a modular approach is likely to be more realistic. A vehicle manufacturing module would require most of the model development resources, as this is where the highest number of variable are to be encountered (material type and material switching, recycled material rate, overall vehicle mass evolution, specific insight into key vehicle components,…), and a vehicle scrappage module, which could be detailed, as this part is usually basic in existing models.

Timeline and Budget

To complete this activity and additional modules, a team of highly qualified consultants over a two-year period is estimated to be needed to research the latest science and evidence, find methodological and modelling approaches and develop a module that could be used along with the existing ForFITS modelling framework.

Annex IV

Environmental and climate impacts of automated and autonomous vehicles – feasibility study

Project time: 12 months – Budget: 80,000 USD

ECE is one of the most active international organization in the field of autonomous and automated vehicles, through the activities of the Global Forum for Road Traffic Safety (WP.1) and the World Forum for the Harmonization of Vehicle Regulations (WP.29). The main focus of the work performed by those bodies is to look at the safe and secure deployment of those technologies on the road and in the vehicles. Such technologies are also expected to have a significant climate and environmental impact.

Automated and autonomous vehicles are expected to drastically change the way people move around and to run, those systems rely on high volume of data exchanged in real-time. Such considerations will alter the transport sector's emission profile and the energy needs to power those technologies. Existing literature shows that there is still significant uncertainty about the potential impact of those technologies on emissions. Developing a modelling approach to simulate the impact of those technologies would need robust science and a deep literature review of the latest evidence.

Workflow

The first steps into tackling such topic and the wide impact it could have on the transport sector as a whole would be to perform a modelling feasibility study to assess the possibility to derive modelling approaches, separated into two categories: (a) the energy and emissions from the technology use and (b) the impact of those technologies on mobility.

If there is enough science and information available to develop a modelling framework, then further resources would be sought to develop ForFITS to include those technologies and be able to simulate its impact on climate and the environment.

Timeline and Budget

A feasibility study would require about a year with a couple of consultants qualified in the matter that have a good understanding of the technologies and the associated IT needs, and on the potential impact of those technologies on mobility, looking at each automated and autonomous technologies individually and a whole..

Annex V

Non-Road Mobile Machinery in ForFITS 1.0

Project time: 18 months – Budget: 200,000 USD

ForFITS is already a multimodal tool. CO_2 emissions from non-transport and Non-Road Mobile Machinery (NRMM), such as agricultural tractors, construction and mining machinery are usually not taken into account in the policy choices, however, they represent a sizeable amount of GHGs.

The contribution of NRMM to total CO_2 emissions could be substantial depending on the characteristics of a country and the structure of its economy. On average, the NRMM sector represents between 10per cent and 15per cent of the CO_2 emissions in the broader sense of the transport sector.

Environment Canada (EC) expressed its interest in ForFITS and particularly in the possibility to expand ForFITS to include NRMM. Funds were made available to perform a feasibility study to investigate the possibility of assessing CO_2 emissions from NRMM such as agricultural tractors, recreational vehicles and construction machinery. This included not only the calculation of historical CO_2 emissions, but also the possibility to make projections of emissions in future years. The feasibility study sponsored by EC concluded that it is possible to develop a NRMM module for ForFITS and it would bring useful knowledge for governments.

The core of the project to deliver a ForFITS module for NRMMs would include the extension of the current scope of the ForFITS through adding other machine types and sectorial indicators. This would assist in making the most relevant policy choice to reach specific energy conservation or emissions mitigation targets in each of the economic sectors, such as agriculture, mining and construction.

Workflow

The feasibility study concluded in 2015 showed that a NRMM module for ForFITS is feasible. Developing an additional module to ForFITS requires to finalize modelling concepts, consolidate the existing database and develop training material for future users.

It would also require an upgrade of the modelling software (going from Vensim 32-bit to Vensim 64-bit).

Timeline and Budget

Initial tasks already performed in 2015 would allow results in a relatively short time. The total budget is estimated to be around 200,000 US dollars from external donors, with the assumption that all training activities would take place in Geneva.