THE REGIONAL CARBON FREEDOM BY REDUCING EMISSIONS AND DEVELOPING SUSTAINABLE FOREST USE IN FINLAND

Kalle Karttunen*[1], Antti Karhunen[1], Mika Laihanen[1], Tapio Ranta[1], Anssi Ahtikoski[2], Soili Kojola[2], Hannu Salminen[2], Jari Hynynen[2], Susanna Kujala[3], Outi Hakala[3], Hannu Törmä[3], Jouko Kinnunen[4]
[1]Lappeenranta-Lahti University of Technology LUT, LUT School of Energy Systems, Laboratory of Bioenergy
[2]Natural Resources Institute Finland,
[3]University of Helsinki, Ruralia Institute,
[4]Statistics and Research Åland
[1]Lönnrotinkatu 7 50100 Mikkeli, Finland
[2]Latokartanonkaari 9, 00790 Helsinki, Finland
[3]Kampusranta 9 60320 Seinäjoki, Finland
[4]P.O. Box 1187 AX-22111 Mariehamn Åland, Finland
*Corresponding author: kalle.karttunen@lut.fi TEL: +358443739377

ABSTRACT: The aim of the study is to promote ways to reach the goals of the carbon neutrality at the South Savo region in eastern Finland by examining the solutions for emission reductions and forest use. The study has taken the first step for reaching the cost-effective carbon neutrality at the regional level in Finland. The carbon dioxide neutral region means that the region's internal activity does not change the carbon content of the atmosphere. The carbon neutral society produces just as much carbon emissions as it can bind from the atmosphere. The study started by updating the regional energy balance and its carbon influence. Second, the carbon impact on forest use was measured. Finally, the cost-efficiency of alternative carbon neutrality solutions will be estimated. The study will be carried out by combining alternative emission reduction solutions and forest management simulations with computable general equilibrium (CGE) modelling. Permanent National Forest Inventory plots were used as an input of forest management simulations. Then, applying a modified CGE model (RegFinDyn), the economic and emission impacts of alternative carbon balance solutions will be assessed at the regional level. Earlier results have shown that a more intensive use of forests decreases the carbon sequestration potential but increases the regional socio-economic benefits. The carbon balance should be compensated either for emission reduction solutions or by controlling the use of forests. It is important to choose the solutions which are not only the emission efficient but also cost-efficient at the regional level.
Keywords: economics, emissions, energy, forestry, regional.

1 INTRODUCTION

The report of IPCC [1] demands more ambitious ways to tackle global warming of 1.5 °C above pre-industrial levels. According to the best estimate from the IPCC, a global carbon budget should stay between 420 and 570 billion tonnes of carbon dioxide to keep global warming under 1.5 °C level. Heat and electricity production account for 25% in global greenhouse gas emissions, agricultural, forestry and other land use by 24% and the third highest is produced by industry sector with 21% share in 2010 (total 49 Gt CO_2 eq.) [2]. Instead of a carbon budget´s uncertainty, it is recommended to use global net zero level emission balance, where sinks equal to emissions and those could be leaded by the country-specific emissions path [3]. This could encourage the smaller regions to achieve their carbon neutrality projects. The carbon dioxide neutral region means that the region's internal activity does not change the carbon content of the atmosphere. The carbon neutral society produces less carbon emissions than it can compensate other ways from the atmosphere. When EU has tightened the goals for carbon neutrality by 2050 [4], there must be even more ambitious targets at the national or regional level.

Total emissions in Finland were 56 million tons of CO_2 eq. in 2017 [5]. Corresponding the share of Finnish CO_2 eq. emissions was 0.15% of total global greenhouse gas emissions in 2010. Energy sector is the biggest source of emissions in Finland with share of 74%, the second one is agriculture (12%) and third is the industry processes and product use (11%) [5]. There are several cities/municipalities [6,7] aiming carbon neutrality in Finland. In this study, we examine the potential of carbon neutrality of South Savo region (19130 km^2) that includes 3 cities and 9 municipalities.

The forests are important part of carbon balance in Finland. Land use, Land Use Change and Forestry "LULUCF" is accounted for the soil, trees, plants, biomass and timber greenhouse gases in national reference level in Finland [8]. On the other hand, the significance and solutions of forest based emission sector differs in relation to specific regions. South Savo is the most important wood supply area in Finland with the largest wood selling incomes. Increasing demand and supply for wood has brought benefits to South Savo regional economy income [9,10], but on the other hand it has also an effect on the environmental sustainability such as carbon balance. According to earlier regional surveys, the total carbon balance has been changing from 2005 [11] to 2010 [12] slightly negatively at South Savo region. Further, wood removal of South Savo has risen very close to the limits of annual forest growth in recent years (growth 9 $M.m^3/a$, wood removal 9 Mm^3 in 2017) [13]. However, carbon sink varies annually, which effects the overall carbon balance.

In addition to national energy and climate strategy [14], the economics of emission reductions has been studied in Finland lately. Long-term energy and climate policy scenarios of Finland have been assessed for the Finnish economy model by utilizing Computable general equilibrium (CGE) model, FINAGE [15]. The results showed that although the scenarios make very different choices of technology and in terms of emission control, choices affect the rest of the economy moderately. The economy and environmental challenges could be studied by using CGE modelling also at regional level [16].

2 MATERIAL AND METHODS

2.1 Regional emission balance

The study focused on the South Savo region in eastern Finland (Figure 1). The area includes 14 cities/municipalities. In this study the regional energy balances were changed to energy emissions and further were used to analyse long-term energy emissions.

Regional energy balance informs the energy production and consumption at the region. Emission analysis of this study was based both earlier regional energy balances in 2006 [17] and 2015 [9], and here in 2017. In addition, regional total emissions have been clarified in 2005 and 2010 by other authorities [12]. Also the energy sector emissions in 1992 and 1999 were included here. Here the starting point in 1990 was estimated (1000 kt CO_2 eq.), which would define the regional minimum emission target, which could be compensated (200 kt CO_2 eq.). Emission reduction should be at least 80% of the emissions from the starting point 1990 and other 20% can be compensated. Regional primary energy sources from the energy balance 2017 were converted to the emissions by using conversion factors (Table I).

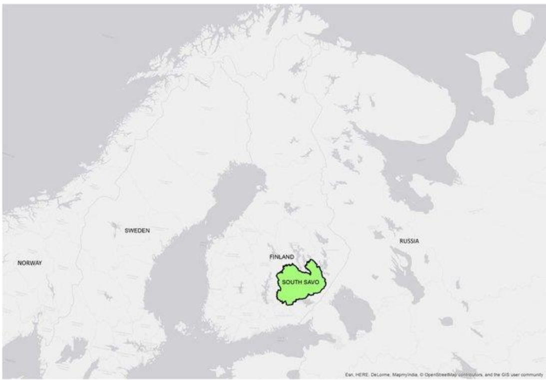

Figure 1: South Savo is located in eastern Finland

Table I: Emission conversion factors used in the study of 2017

	Peat	Heavy fuel oil	Light fuel oil	Coal	Gas	GWP-factor
CO2, [gCO2/MJ]	105,9	78,8	72	92,7	64,9	1
CH4, [mgCH4/MJ]	2 - 30	1	1 - 5	1	1 - 5	25
N2O, [mgN2O/MJ]	2 - 7	1	1 - 4	1	1	298

2.2 Regional forest carbon

The current forest resources on the South Savo region were represented by the 11th National Forest Inventory "NFI" (2009-2013) data. Stand projections were based on the Motti stand simulator. Motti is a stand-level forest management and decision support tool that consists of stand-level models and distance-independent individual-tree models for predicting stand dynamics (regeneration, growth and mortality) and stand structure [18, 19]. Growth and yield models of the Motti are based on extensive empirical data covering whole commercial wood production area in Finland with different site types and tree species [19, 20, 21]. The predicted response to different forest management practices are based on empirical data, which covers all common forest management practices applied in practical forestry in Finland over recent decades. The performance of the Motti simulator has been evaluated in permanent long-term experimental data [eg. 22, 23, 24] as well as in Finnish NFI data [18]. Motti stand simulator has been applied widely in analyses at different spatial levels from stand-level to regional and national levels [25, 26].

In this study, the aim was to analyse the baseline development of regional wood carbon level of living trees by 2040 based on the current forest structure and the simulated forest development. In the scenario (based on the simulation) regional cutting was assumed to stay at current level, ca. 7.3 M.m^3 (average 2015-2017). As well as forest silviculture represented the current situation.

The wood storage was kept at the same level during the period. The soil and other land-use carbon was excluded in this study. The simulation results presented the 5 year periods starting from 2013 and ending at 2038.

3 RESULTS

3.1 Regional emissions

Regional energy production of South Savo consisted of renewable wood fuels (41%) and other primary energy production sources (59%) in 2017 (total energy: 7 128 GWh) (Figure 2). Corresponding energy consumption of South Savo included heating (41%), electricity (own production 11%, import 20%), transportation (23%) and energy loses (11%).

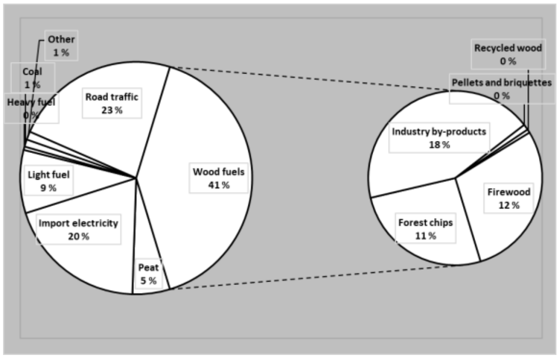

Figure 2: Primary energy production sources of South Savo in 2017 (7 128 GWh)

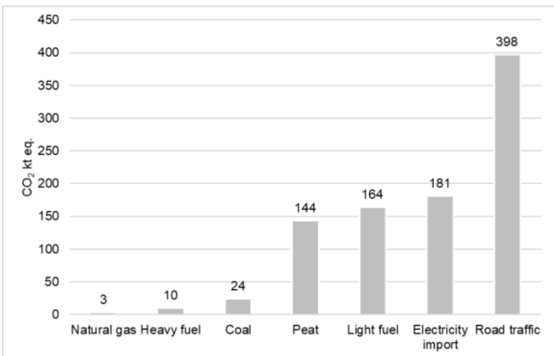

Figure 3: Total regional emissions of primary energy sources of South Savo in 2017 (925 kt CO_2 eq.)

Energy sector emissions of South Savo was totally 925 kt CO_2 eq. in 2017 according to energy balance (2.2% of total emissions of Finland), which were divided on primary energy sources including road traffic and import electricity (Figure 3). Emissions were collected from each city/municipal areas (14 units) separately, of which the biggest emissions were in Mikkeli city (289 kt CO_2 eq, 31% of total emissions of South Savo region).

The biggest source of regional emissions was the road traffic, 41% (398 kt CO_2 eq.).

3.2 Regional carbon balance development

Emissions have been analysed according to the energy production and total level for several times at the region of South Savo (Figure 4). The results showed that even the emissions have been decreased, the emission reduction should be strengthened in the near future.

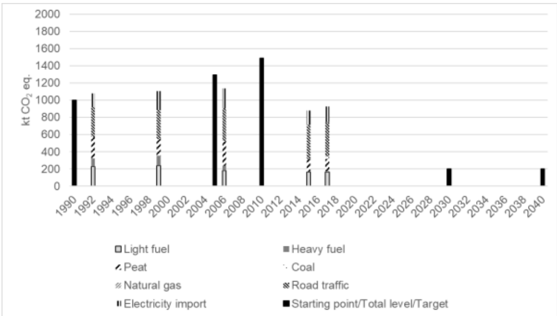

Figure 4: Regional emissions of South Savo from 1990 to 2040

Preliminary results of the forest management simulations showed that the changes in the carbon storage of living trees varied easily between the 5-year periods (Figure 5), being on average -1664 kt CO_2 between the simulation period from 2013 to 2038, in 25 years. It must be noticed that the corresponding change represents 0.8% of forest carbon storage level at region, which was 201 505 kt CO_2 in the end of simulation period. The starting point of the carbon storage of living trees was 199 841 kt CO_2 at the region in the beginning of simulation.

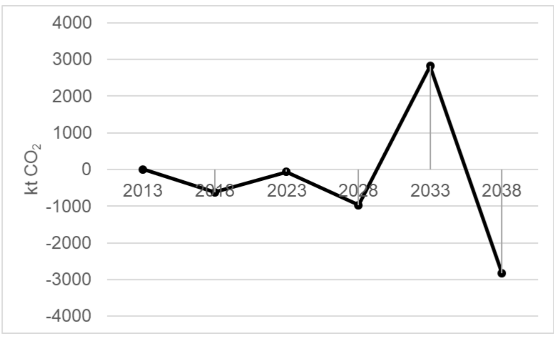

Figure 5: Regional change in the carbon storage of living trees based on the preliminary results of forest management simulation of 25 years (wood carbon, soil carbon excluded)

4 CONCLUSION

The regional carbon balance of energy sector and change of forest carbon storage was measured at the South Savo region of Finland. The development in recent years has showed that even though the energy emissions have been decreased, the change of forest carbon storage has developed oppositely. On the other hand, the study showed that the forest carbon sink development is still positive in the long-run even if the cutting and forest silviculture would stay at the current level (BAU).

However, annual change of forest carbon storage would be significantly lower (average 1664 kt CO_2 eq. wood carbon sink in 25 years) than carbon sink from the early study 2008-2010 (1200-4000 kt CO_2 eq. annual wood carbon sink) [27]. Carbon balance analysis showed the emission reduction and carbon sequestration requirements to achieve regional carbon freedom. This study indicated the need of actions to increase forest carbon sink or using other compensation methods to cover regional emissions. Otherwise, the emissions must be even at lower level, which seems unrealistic for this timetable.

There are several ways to reach theoretically carbon freedom at South Savo by using more sustainable energy sources [28], but it should be done cost-efficiently. The regional challenge is the private decision making towards increased use of renewable resources. Globally, Stern review on the economics of climate change [29] has shown that emission reductions will be more affordable than not stopping global warming. Nationally, the emission reductions can be done economically reasonable in Finland [15]. In addition, the statistics of Finland shows that Gross Domestic Product (GDP) has been increasing at the same time when the emissions have been falling [30]. Recently, solutions for national cost-efficient emission reduction has been especially presented by electrifying transport sector and increasing wind power usage [31], but regional solutions may differ.

The cost-efficiency of alternative energy solutions should be compared with the economic modelling at the regional level. Emission reduction potential should to be studied for the separate regions to analyse their own specific features either by reducing emissions, increasing carbon storages or buying compensation shares. Options will give local companies, authorities and public emission reduction targets and controlling tools to the practice decision making. We will continue to identify the most cost-effective solutions by utilizing CGE modelling with specific statistical information at the regional level.

5 REFERENCES

[1] IPCC (2018). Global Warming of 1.5 ºC. Special Report. https://www.ipcc.ch/sr15/

[2] IPCC, 2014. Summary for Policymakers, In: Climate Change 2014, Mitigation of Climate Change, Cambridge: Cambridge University Press.

[3] Peters, G.P., 2018. Beyond carbon budgets. Nature Geoscience, 11(6), p.378.

[4] European commission, climate action. 2050 long term strategy. https://ec.europa.eu/clima/policies/strategies/2050_en

[5] Suomen virallinen tilasto (SVT): Kasvihuonekaasut [verkkojulkaisu]. ISSN=1797-6049. 2017. Helsinki: Tilastokeskus [cited: 7.5.2019]. Available:http://www.stat.fi/til/khki/2017/khki_2017_2019-03-28_tie_001_fi.html

[6] Hiilineutraali Helsinki 2035 – toimenpideohjelma. Helsingin kaupungin keskushallinnon julkaisuja 2018:4. ISBN 978-952-331-486-2. https://www.hel.fi/static/liitteet/kaupunkiymparisto/

julkaisut/julkaisut/HNH-2035-toimenpideohjelma.pdf

[7] Il mastosuunnitelma 2029. Turun kaupungin kestävä ilmasto- ja energiatoimintasuunnitelma 2029. https://www.turku.fi/sites/default/files/atoms/files/ilmastosuunnitelma_2029.pdf

[8] National Forestry Accounting Plan for Finland. Ministry of Agriculture and Forestry (MMM) & Natural Resources Institute Finland (Luke). https://mmm.fi/documents/1410837/1504826/Suomen+vertailutasoraportti/96423a2c-c70d-3daa-ef7f-b867b321600a

[9] Karttunen, K., Karhunen, A., Laihanen, M., Ranta, T., Ahtikoski, A., Huuskonen, S., Kojola, S., Lehtonen, M, Salminen, H. & Hynynen, J. (2017). Metsätoimialan aluetaloudellinen vaikuttavuus Etelä-Savossa –Tulevaisuusvisio 2020-luvulla. LUT Scientific and Expertise Publications / Raportit ja Selvitykset-Reports 71. http://urn.fi/URN:ISBN:978-952-335-081-6

[10] Kujala, S., Kinnunen, J, Hakala, O, Törmä, H. Metsätoimialan tulevaisuuden skenaarioiden aluetaloudelliset vaikutukset Etelä-Savossa. Mikkeli: Helsingin yliopisto, 2017. 34 Sivumäärä (Helsingin yliopisto Ruralia-instituutti, Raportteja; 172).

[11] Mäkelä, L. 2008. Etelä-Savon kasvihuonekaasutase 2005. Etelä-Savon ympäristökeskuksen raportteja 3/2008. ISBN 978-952-11-3226-1(PDF).

[12] Koponen, H. 2012. Etelä- ja Pohjois-Savon maakuntien kasvihuonekaasutaseet 2010. Raportteja 59 | 2012. ISBN 978-952-257-565-4 (PDF).

[13] Luke statistics. https://stat.luke.fi/

[14] Government report on the National Energy and Climate Strategy for 2030. Publications of the Ministry of Economic Affairs and Employment, Energy, 12/2017. ISBN: 978-952-327-199-9

[15] Honkatukia, J. 2019. Vaikutukset kansantalouteen. In publication: Koljonen et al. 2019. Pitkän aikavälin kokonaispäästökehitys. Valtioneuvoston selvitys- ja tutkimustoiminnan julkaisusarja 24/2019. ISSN 2342-6799 (pdf).

[16] Banerjee, O., Cicowiez, M., Horridge, M., & Vargas, R. (2016). A Conceptual Framework for Integrated Economic–Environmental Modeling. The Journal of Environment & Development, 25(3), 276–305. https://doi.org/10.1177/1070496516658753

[17] Karhunen, A. 2008. Etelä-Savon Energiatase 2006. Diplomityö. Lappeenrannan Teknillinen Yliopisto. http://lutpub.lut.fi/handle/10024/36431

[18] Hynynen J., Ahtikoski A., Siitonen J., Sievänen R., Liski J. (2005). Applying the MOTTI simulator to analyse the effects of alternative management schedules on timber and non-timber production. For. Ecol. Manage. 207: 5-18. doi:10.1016/j.foreco.2004.10.015. http://dx.doi.org/10.1016/j.foreco.2004.10.015

[19] Salminen H., Lehtonen M., Hynynen, J. (2005). Reusing legacy FORTRAN in the MOTTI growth and yield simulator. Computers and electronics in agriculture, 49(1), 103-113.

[20] Matala, J., Hynynen, J., Miina, J., Ojansuu, R., Peltola, H., Sievänen, R., Väisänen, H. & Kellomäki, S. (2003). Comparison of a physiological model and a statistical model for prediction of growth and yield in boreal forests. Ecological Modelling,161(1), 95-116.

[21] Hynynen, J., Ojansuu, R., Hökkä, H., Siipilehto, J., Salminen, H., & Haapala, P. (2002). Models for predicting stand development in MELA System. Metsäntutkimuslaitos.

[22] Huuskonen, S. and Ahtikoski. A. (2005). Ensiharvennuksen ajoituksen ja voimakkuuden vaikutus kuivahkon kankaan männiköiden tuotokseen ja tuottoon, Metsätieteen aikakauskirja 2 (2005) 99-115.

[23] Huuskonen, S (2008). The development of young Scots pine stands – precommercial and first commercial thinning [In Finnish], Dissertationes Forestales 62 (2008).

[24] Mäkinen, H., Hynynen, J. and Isomäki. A. (2005). Intensive management of Scots pine stands in southern Finland: First empirical results and simulated further development. Forest Ecology and Management 215 (2005) 37-50.

[25] Hynynen, J., Salminen, H., Ahtikoski, A., Huuskonen, S., Ojansuu, R., Siipilehto, J., Lehtonen, M. and Eerikäinen, K. 2015. Long-term impacts of forest management on biomass supply and forest resource development: a scenario analysis for Finland. European Journal of Forest Research 134: 415-431. doi 10.1007/s10342-014-0860-0

[26] Mönkkönen, M., Juutinen, A., Mazziotta, A., Miettinen, K., Podkopaev, D., Reunanen, P., Salminen, H. & Tikkanen, O. P. (2014). Spatially dynamic forest management to sustain biodiversity and economic returns. Journal of environmental management, 134, 80-89.

[27] Monni, S. 2012. Etelä- ja Pohjois-Savon maankäyttösektorin kasvihuonekaasutase 2008-2010. Benviroc Oy. https://docplayer.fi/20366398-Etela-ja-pohjois-savon-maankayttosektorin-kasvihuonekaasutase-2008-2010.html

[28] Suprisman Ilham. 2018. Sustainable energy system for South Savo in 2040. LUT University thesis. http://urn.fi/URN:NBN:fi-fe2018120349654

[29] The Stern review. The economics of climate change. https://doi.org/10.1017/CBO9780511817434

[30] Suomen kasvihuonekaasupäästöt 1990-2016. Tilastokeskus. ISBN 978–952–244–584–1 (pdf). http://www.stat.fi/static/media/uploads/tup/khkinv/suomen_kasvihuonekaasupaastot_1990-2016_final.pdf

[31] Sitra and McKinsey (2018), Cost-efficient Emission Reduction Pathway to 2030 for Finland: Opportunities in Electrification and Beyond, Sitra Studies 140. https://media.sitra.fi/2018/11/30102722/cost-efficient-emission-reduction-pathway-to-2030-for-finland.pdf.

6 ACKNOWLEDGEMENTS

We want to thank following supporters of the Carbon free South Savo project funding; European Regional Development Fund (ERDF), Suur-Savon Energiasäätiö & Mikkeli region development fund.