

Supplementary Material S3. Results of Environmental Assessment.

1. Scenarios Assessment, Marginal Data

1.1. Energy Mixes, Marginal Data

Marginal electricity mixes for the reference and four base scenarios are presented in Table S3.1. The mixes were created based on Sköldberg and Unger [1], assuming that Reference scenario in the current project is consistent with the reference scenario described in Sköldberg and Unger [1], Scenarios 1 and 4 are consistent to the scenario “Fossils” and Scenarios 2 and 3 are similar to the scenario “CO₂ cap” [1].

Table S3.1. Marginal electricity mixes for the reference scenario and four base scenarios.

Fuel	Reference	Scenarios 1&4	Scenarios 2&3
Natural gas	19 %	125 %	−2.6 %
Coal + Oil CCS*		15 %	
Coal + Oil (50/50%)	69 %	−51 %	97.5 %
Biofuels, (50/50%)	6 %	1.5 %	2.6 %
Peat	3%	0.75%	1.3%
Wind power	6 %	9.5 %	2.5 %
Total	100 %	100 %	100 %

*: Carbon Capture and Storage/Sequestration

The marginal heat mixes for the reference and base scenario are presented in Table S3.2. The mixes are created based on the marginal mixes for electricity production, assuming that most of the heat would be generated at the combined heat and power production.

Table S3.2. Marginal heat mixes for the reference and four base scenarios.

Fuel	Reference scenario	Scenarios 1&4	Scenarios 2&3
Natural gas	96 %	0 %	0 %
Biofuel, peat	4 %	100.00 %	44 %
Coal+Oil (conventional)	0 %	0 %	56 %
Total	100 %	100 %	100 %

For trucks, buses and cars the marginal fuel mixes are assumed to be the same as the average ones.

1.2. Results Using Marginal Data on Energy Supply

The potential environmental impacts in the case of the marginal energy use are presented in Figure S3.1. Scenarios 1 to 4 are compared to the Reference scenario, which is set to 100 %. The pattern of the impacts distribution is the same as with average energy applied, just with a different magnitude of change (see section 3 of the paper).

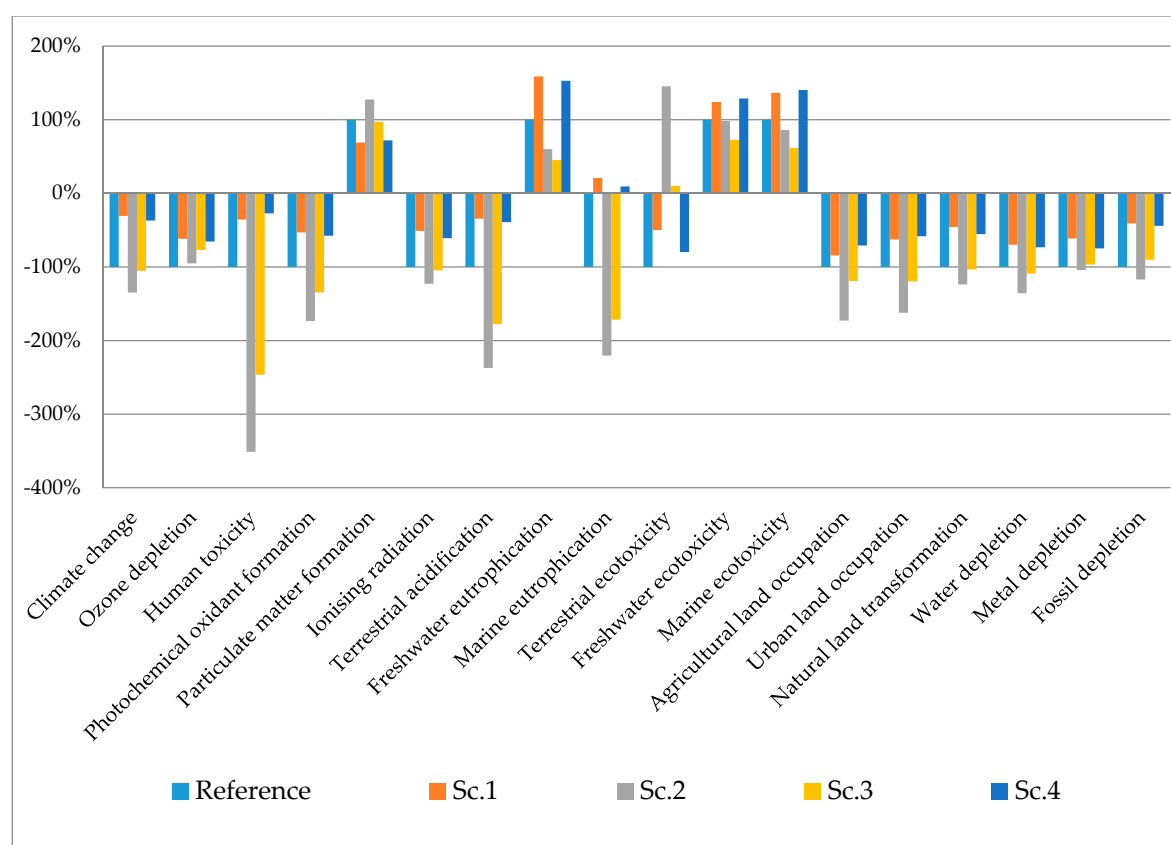


Figure S3.1. Relative environmental impacts for the four base scenarios compared to the reference scenario set to 100% (marginal data).

2. Policy Instruments Assessment, Average Data

2.1. Assessment of Policy Instruments in Reference Scenario

The policy instruments are described in Finnveden et al. [26]. The results of the environmental impact assessment of Electricity certificates, Climate incineration tax and Weight based waste fee (alt. 2) policy instruments in comparison to the “no action” alternative are presented on the Figure S3.2.

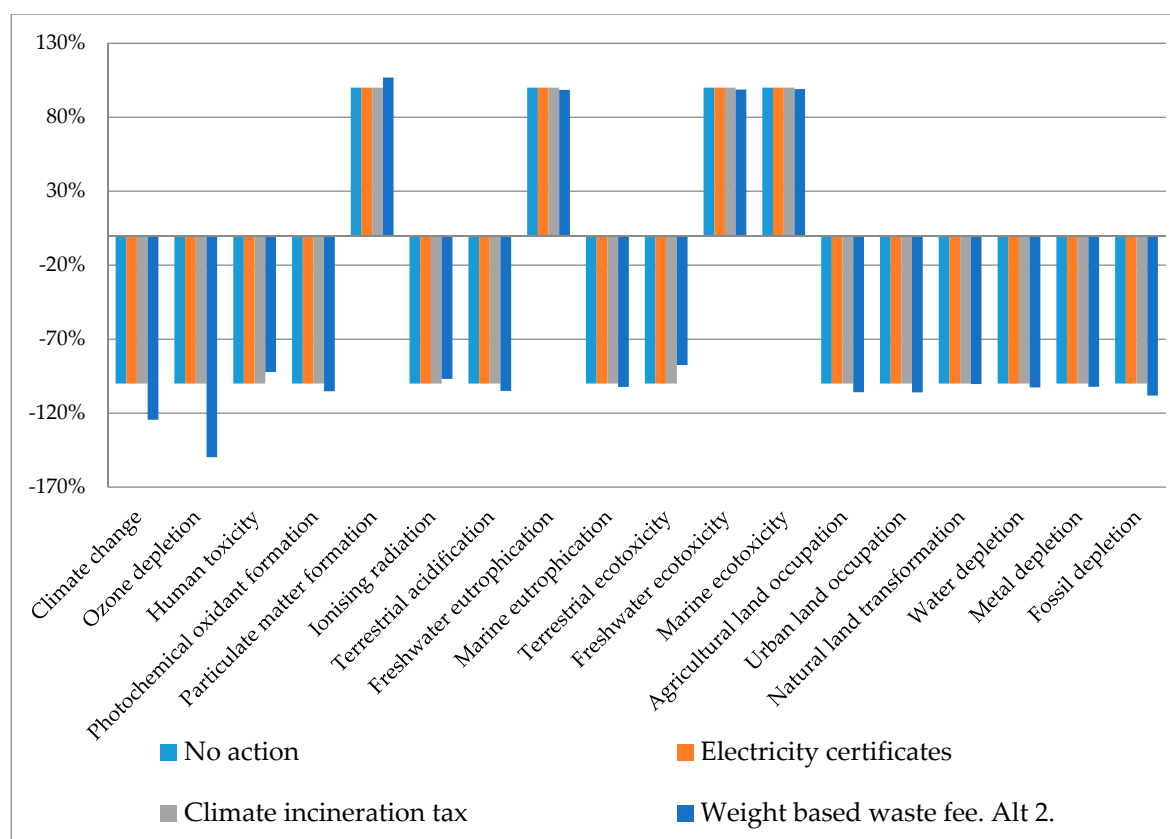


Figure S3.2. Relative environmental impacts of policy instruments in comparison to “no action” alternative (set to 100%) in Reference Scenario.

As it is seen from the graphs the Electricity certificates and Climate incineration tax policy instruments do not have any impact. The reason for that is that the environmental assessment is based on the results of the economic assessment and therefore is restricted by the results of the economic model. The economic model shows no change, because Climate incineration tax is not high enough to make the changes cost-effective, while in case of Electricity certificates there is no room for change since the maximal amount of renewable material waste is already incinerated in “no action” alternative [25].

Weight based waste fee (alt. 2) on the other hand shows to have a positive effect on the system. The introduction of this policy instrument in this version is assumed to lead to the increased source sorting of materials and organic waste and therewith increased recycling and home composting [26]. Since home composting is not considered either in generated or treated waste in NatWaste and SWEA models, it is only increased recycling that affects the system.

In the result, the environmental benefit from the waste treatment system is expected to increase significantly in general (from 2% in Metal depletion impact category till 25% for Climate change and 50% for Ozone layer depletion) due to the increased recycling (mainly of steel and aluminum).

The exceptions constitute few impact categories. For the Human toxicity the reason of the decrease of the environmental benefit is the emission from some of the steel recycling processes and the chemicals used in newsprint recycling.

The results of the Cumulative energy demand assessment of Electricity certificates, Climate incineration tax and Weight based waste fee (alt. 2) policy instruments in comparison to the “no action” alternative are presented in Figure S3.3.

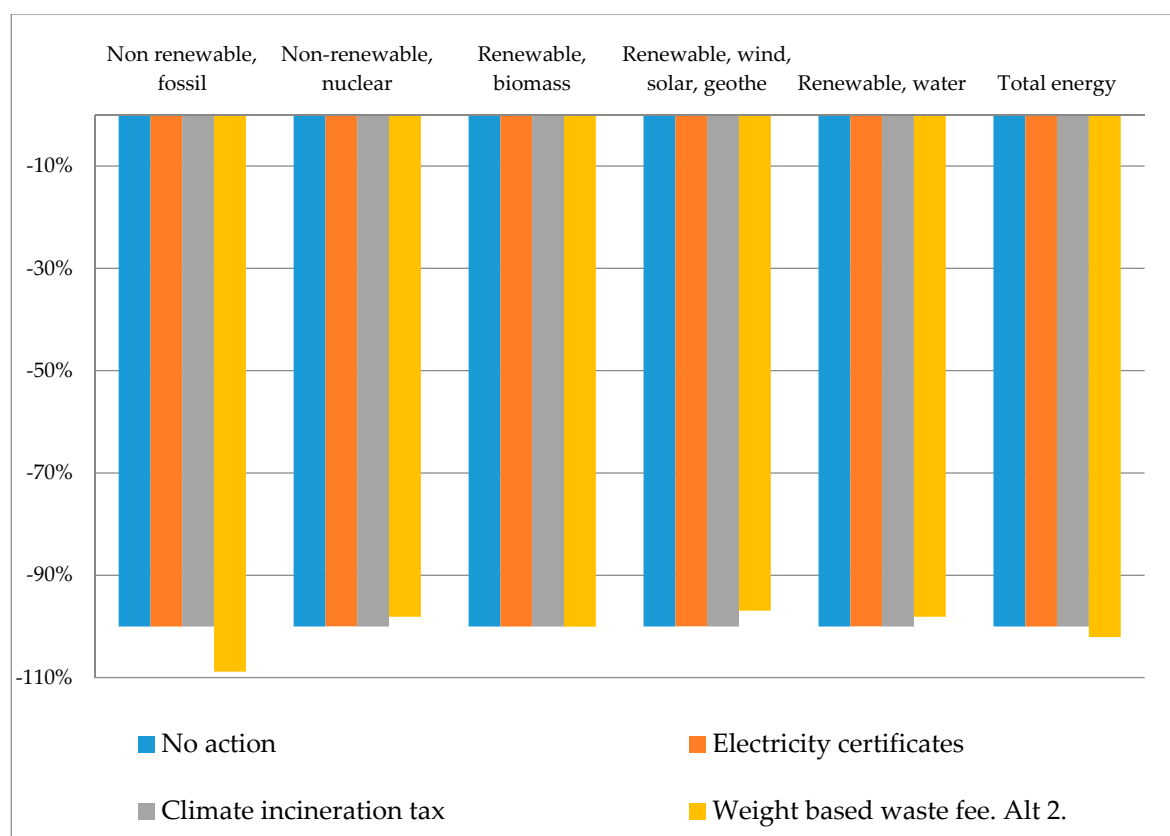


Figure S3.3. Relative Cumulative energy demand for the policy instruments in comparison to “no action” alternative (set to 100%) in Reference Scenario.

The same pattern as for other environmental impacts is observed - Electricity certificates and Climate incineration tax show no change, Weight based waste fee (alt. 2) leads to improvements regarding fossil and total energy. The electricity use is however increased.

Two versions of a Resource tax were assessed: tax on non-renewable materials (“iron”) and tax on fossil raw materials (“plastic”)

The relative environmental impacts of the Resource tax (iron) are presented on the Figure S3.4. Both, impact from the waste treatment system and benefit of the avoided production, are taken into account. According to Forsfält [2] the tax on the non-renewable materials would result in a relatively small waste reduction (35 ktonne in the reference scenario), which leads to almost no changes in terms of environmental impacts (less than 1% of improvement in each impact category). In the same way the assessment of the cumulative energy demand was calculated for the policy instrument. The results are presented on the Figure S3.5.

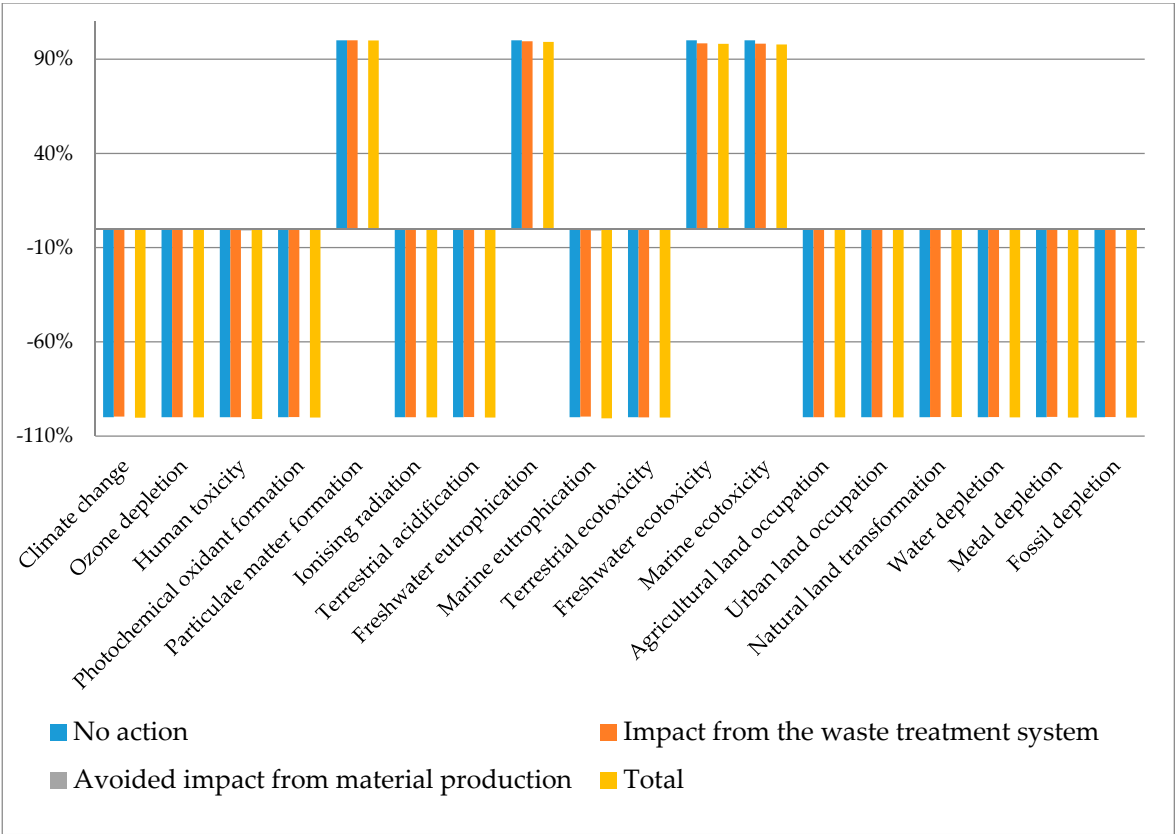


Figure S3.4. Environmental impacts of the introduction of the Resource tax (iron) in comparison to the “no action” alternative (set to 100%) in Reference Scenario.

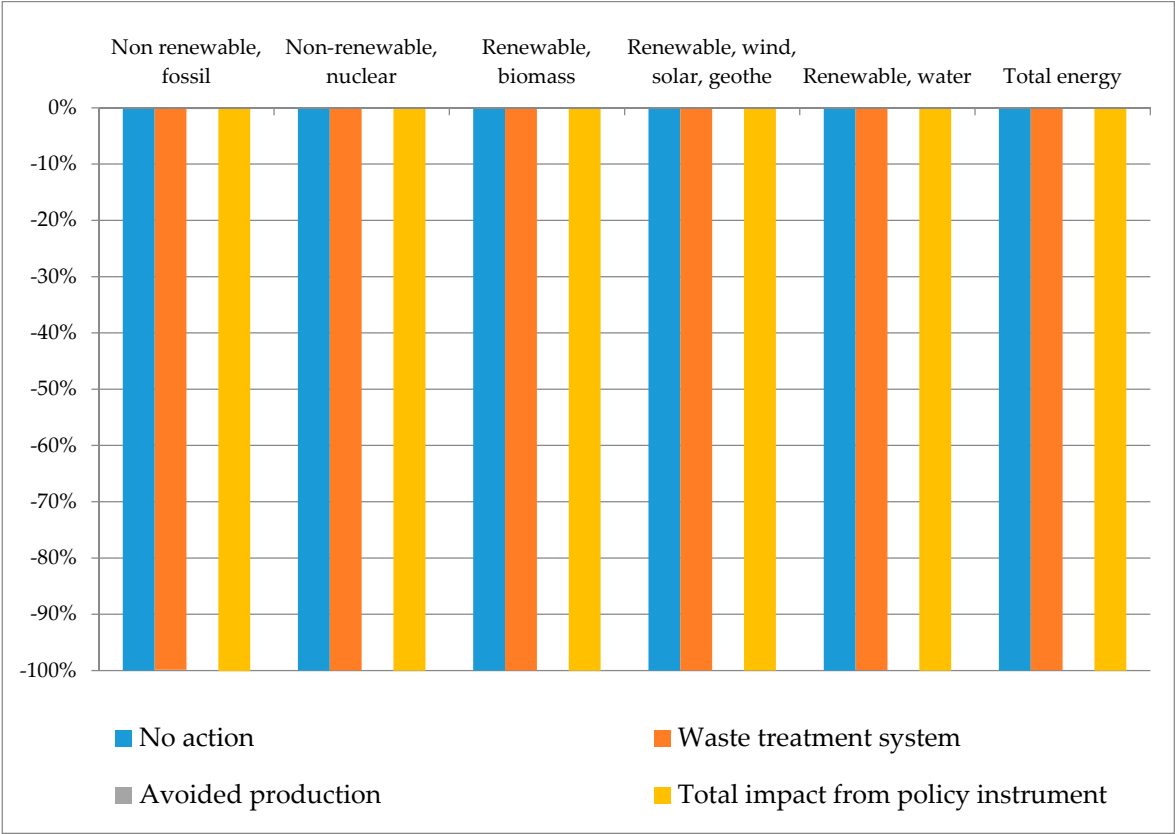


Figure S3.5. Cumulative energy demand for the policy instrument Resource tax (iron) in comparison to “no action” alternative (set to 100%) in Reference Scenario.

The relative environmental impacts of the Resource tax (plastic) are presented on the Figure S3.6. Both, impact from the waste treatment system and benefit of the avoided production, are taken into account. Resource tax (plastic) would result in a very small reduction of plastic waste according to the economic analysis [2], but would also affect various economic sectors and therefore would give a reduction of metal and inert waste. But the total waste reduction would still be relatively small (20 ktonne in the reference scenario), which again gives less than 1% of improvement for the environmental impact in each impact category.

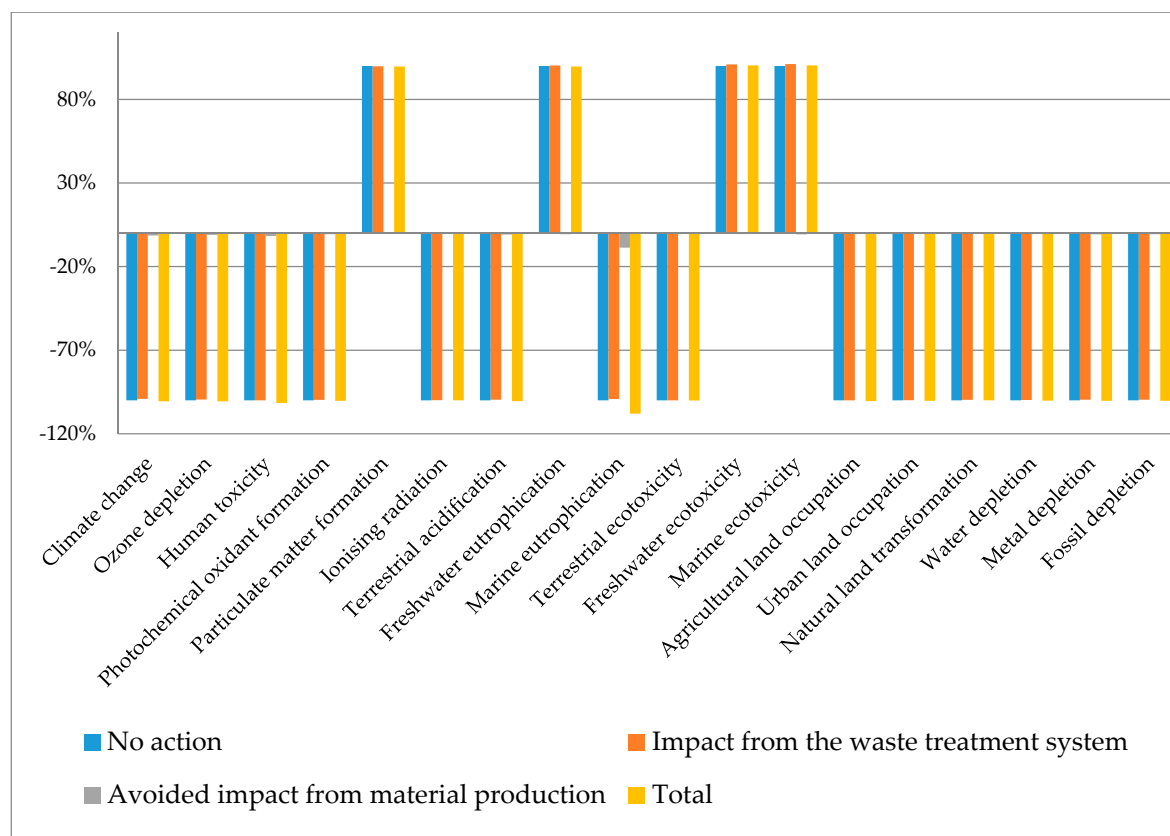


Figure S3.6. Environmental impacts of the introduction of the Resource tax (plastic) in comparison to the “no action” alternative (set to 100%) in Reference Scenario.

In the same way the assessment of the cumulative energy demand was calculated for the policy instrument. The results are presented on the Figure S3.7.

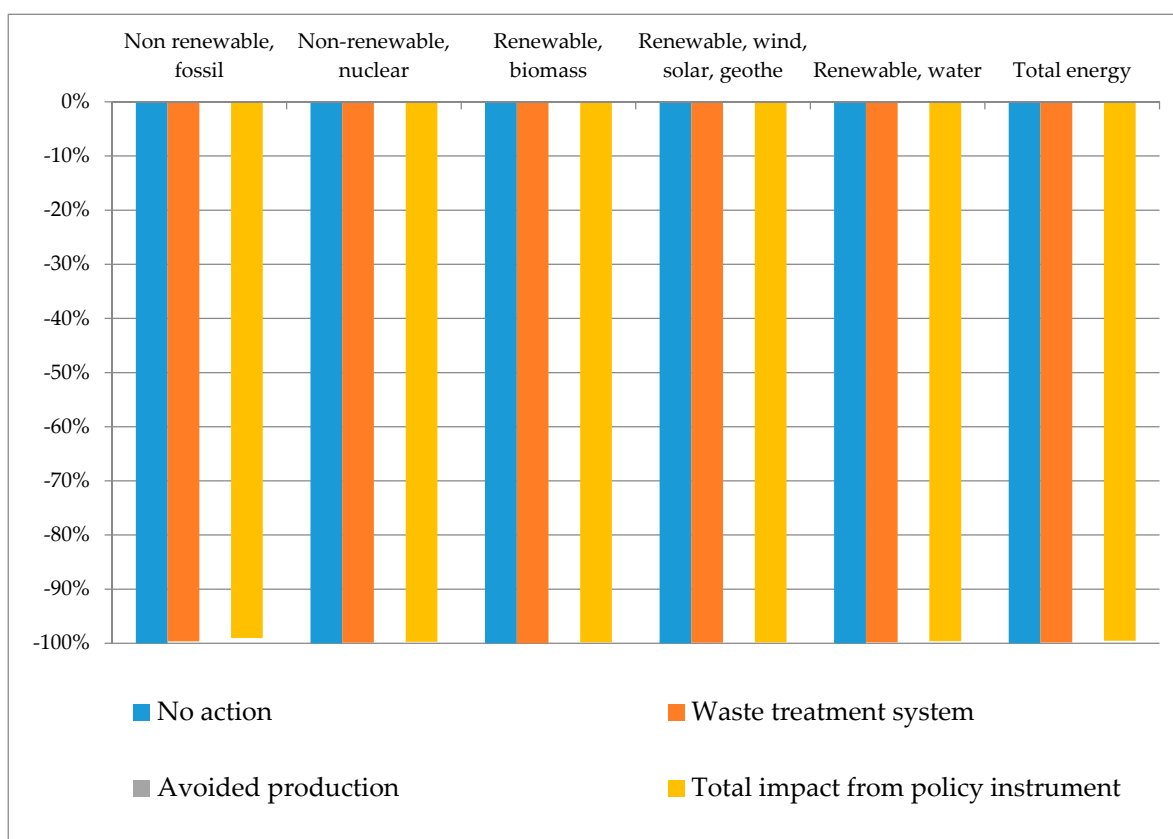


Figure S3.7. Cumulative energy demand for the policy instrument Resource tax (plastic) in comparison to the “no action” alternative (set to 100%) in Reference Scenario.

2.2. Assessment of Policy Instruments in Scenario 1.

The relative results for the potential environmental impacts for the policy instruments Electricity certificates, Climate incineration tax and Weight based waste fee (alt. 2) are presented in Figure S3.8.

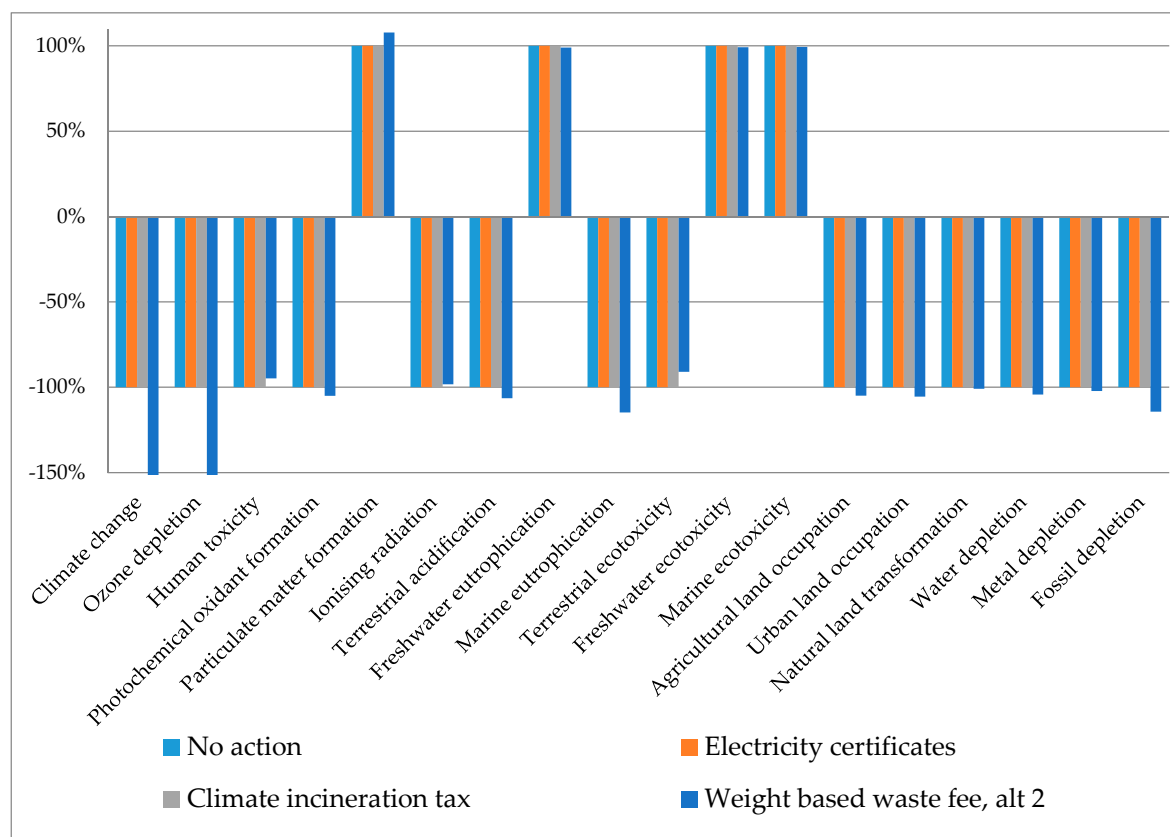


Figure S3.8. Environmental impacts of the introduction of the policy instruments in comparison to the “no action” alternative in Scenario 1.

In general the picture of the potential impacts has the same pattern as the one in the reference scenario. The difference can be found for the Weight based waste fee, alt.2 in the Climate change and Ozone depletion categories, where the magnitude of change differs from the reference scenario. The reason for this is the lower amount of waste in the system, and therefore lower negative impacts from the treatment, which allows the positive effects from the introduction of the policy instrument to be more noticeable.

The relative results of the Cumulative energy demand assessment for the policy instruments in comparison to the “no action” alternative are presented in the Figure S3.9.

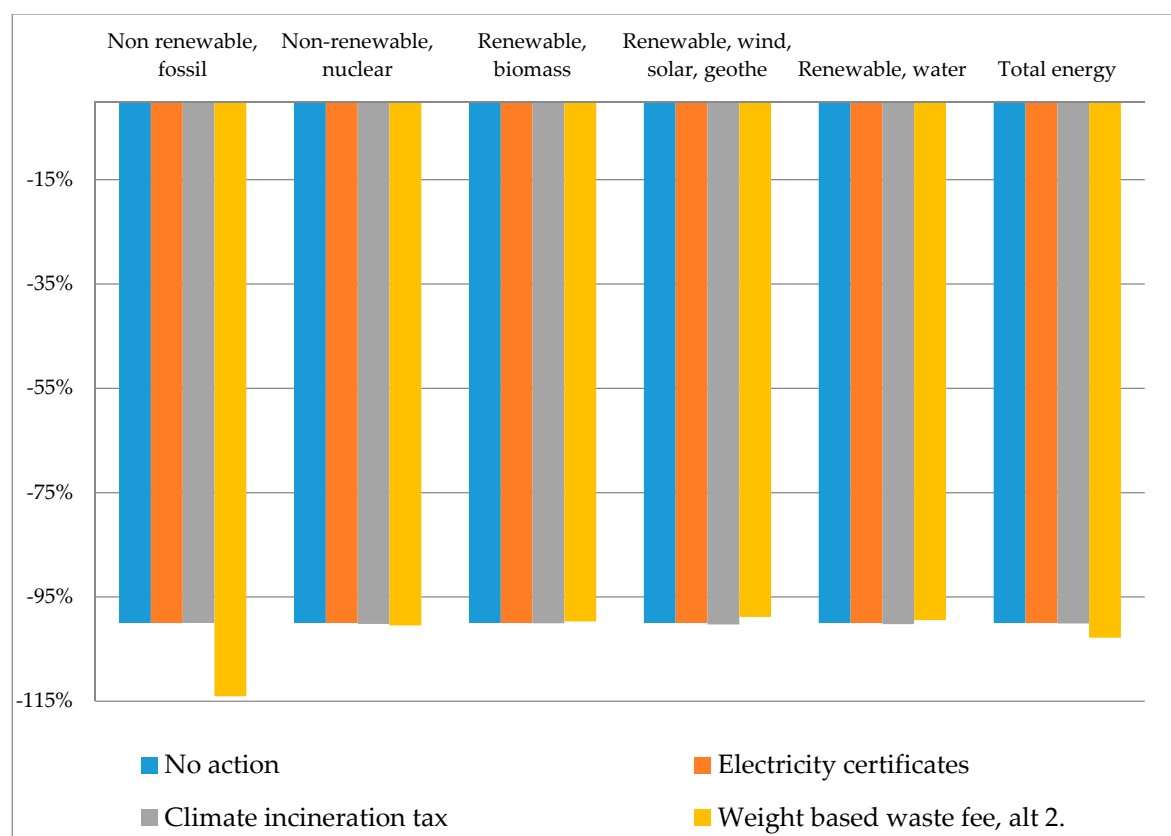


Figure S3.9. Relative cumulative energy demand for the policy instruments in comparison to “no action” alternative set to 100% in Scenario 1.

The potential environmental impacts from the introduction of the Weight based waste fee, alt. 1 in comparison to the “no action” alternative are presented in the Figure S3.10. Since the waste amounts are rather low in Scenario 1 already (compared to “no action” alternative), the benefit of waste prevention appears to be even higher than the benefit of waste treatment in some impact categories and shows the policy instrument to be very efficient for Climate change for example.

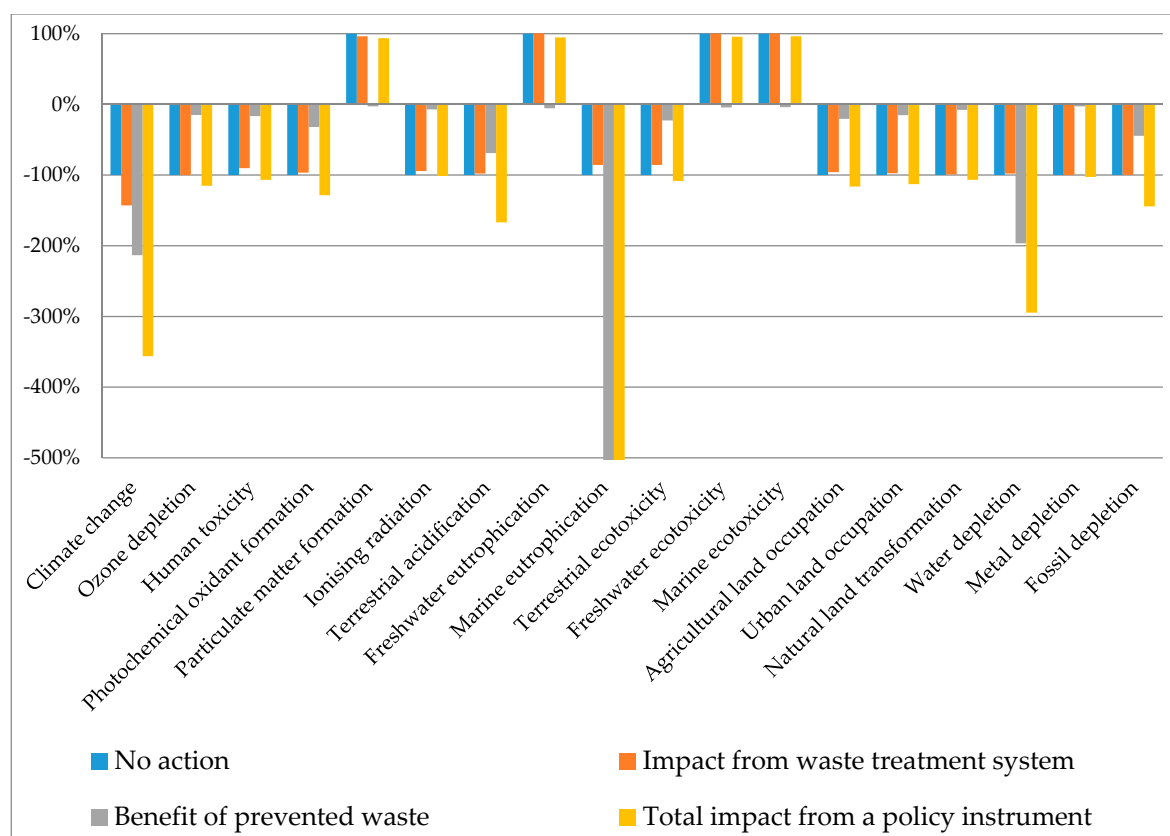


Figure S3.10. Environmental impacts of the introduction of the policy instrument “Weight based waste fee, alt. 1” in comparison to the “no action” alternative (set to 100%) in Scenario 1.

The relative results for potential Cumulative energy demand for the Weight based waste fee (alt.1) are presented in Figure S3.11. The pattern is the same as in the “no action” alternative and shows the positive effect of this policy instrument introduction.

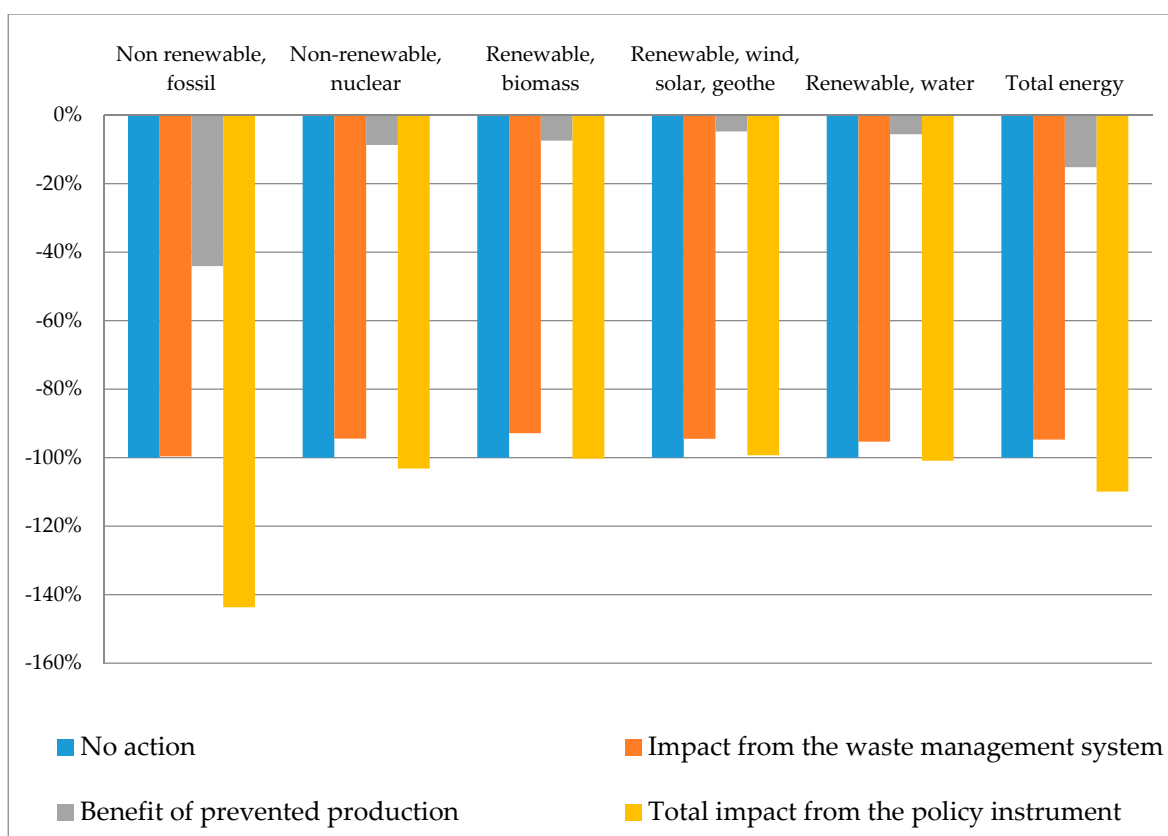


Figure S3.11. Relative Cumulative energy demand for the policy instrument “Weight based waste fee, alt. 1” in comparison to the “no action” alternative (set to 100%) in Scenario 1.

2.3. Assessment of Policy Instruments in Scenario 2.

The relative results for the potential environmental impacts for the policy instruments Electricity certificates, Climate incineration tax and Weight based waste fee (alt. 2) in Scenario 2 are presented in Figure S3.12.

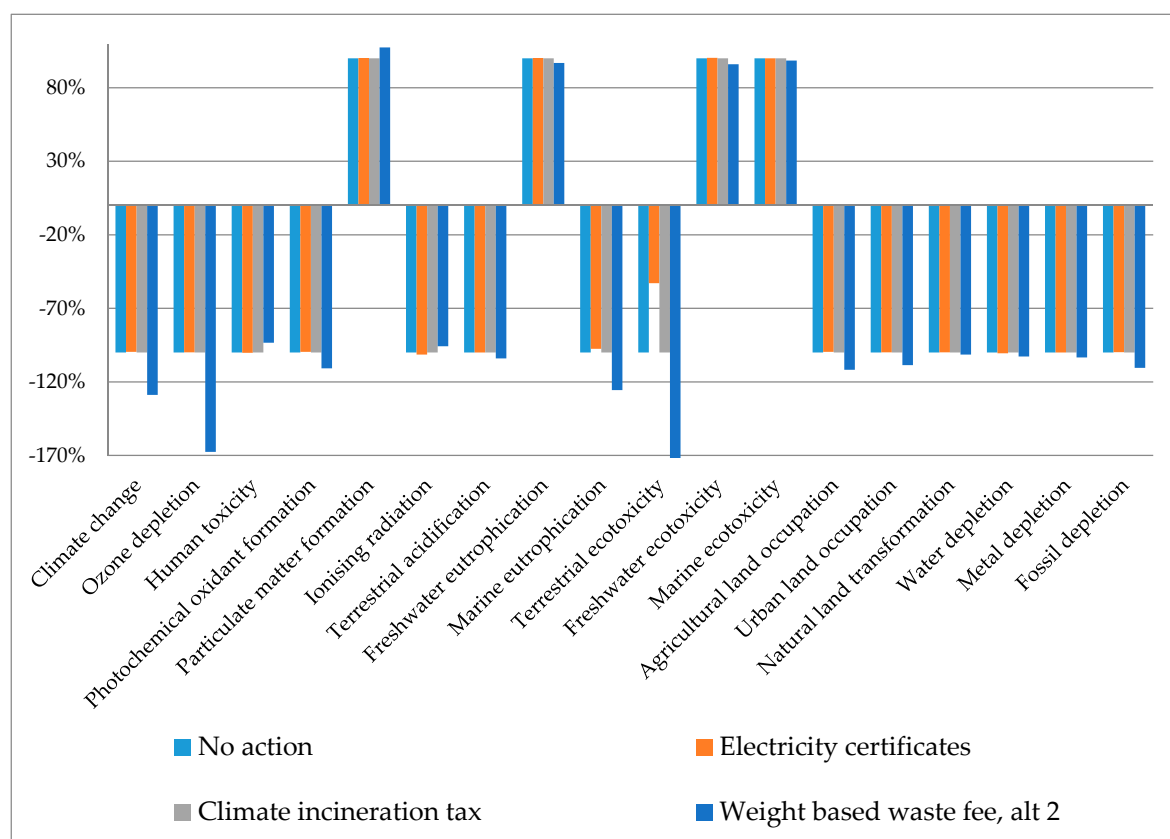


Figure S3.12. Environmental impacts of the introduction of the policy instruments in comparison to the “no action” alternative in Scenario 2.

The pattern of the environmental impacts picture is similar to the one in reference scenario with the exception for more radical changes in Weight based waste fee (alt. 2). Scenario 2 implies the higher amount of waste in comparison with “no action” alternative therefore increased recycling in this case gives even more benefit.

The same situation can be observed in the potential Cumulative energy demand (Figure S3.13).

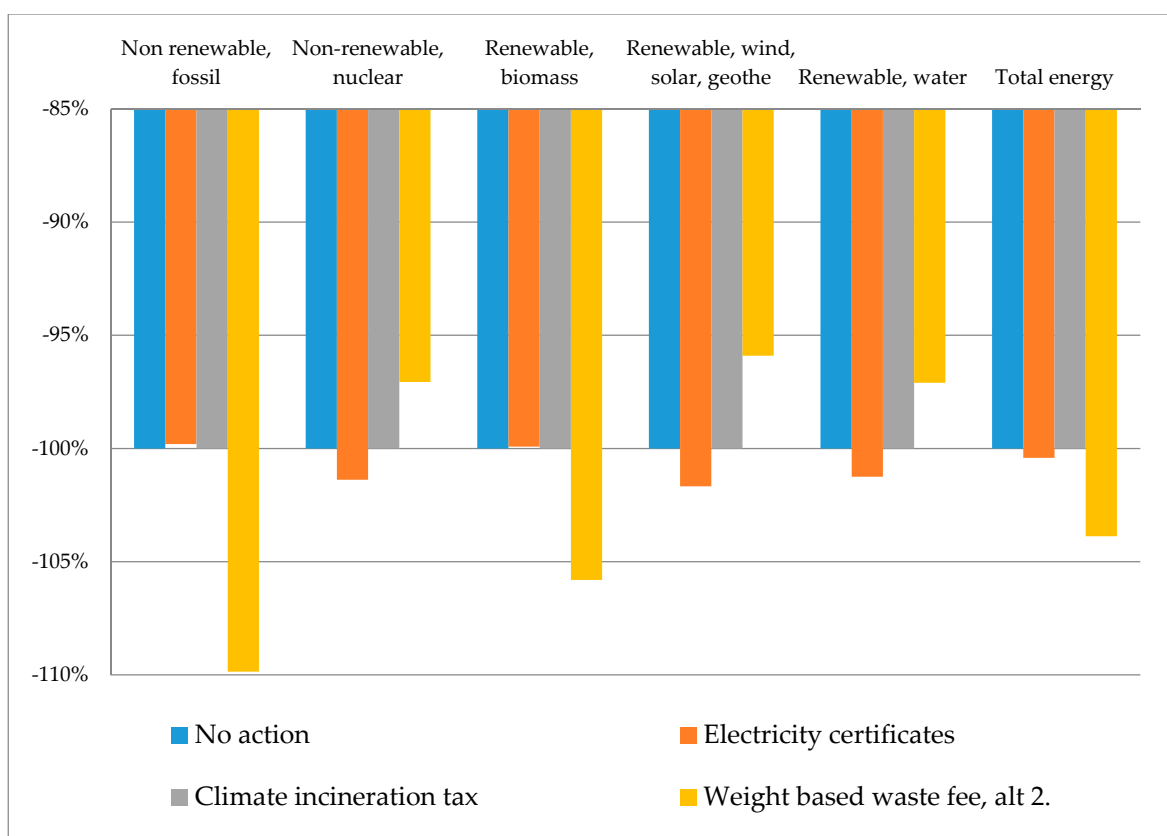


Figure S3.13 Relative Cumulative energy demand for the policy instruments in comparison to “no action” alternative set to 100% in Scenario 2.

In a similar way as Weight based waste fee (alt.2) the Weight based waste fee (alt.1) shows similar pattern as in the Reference scenario, but with even higher environmental benefit due to the increased waste amounts (Figure S3.14).

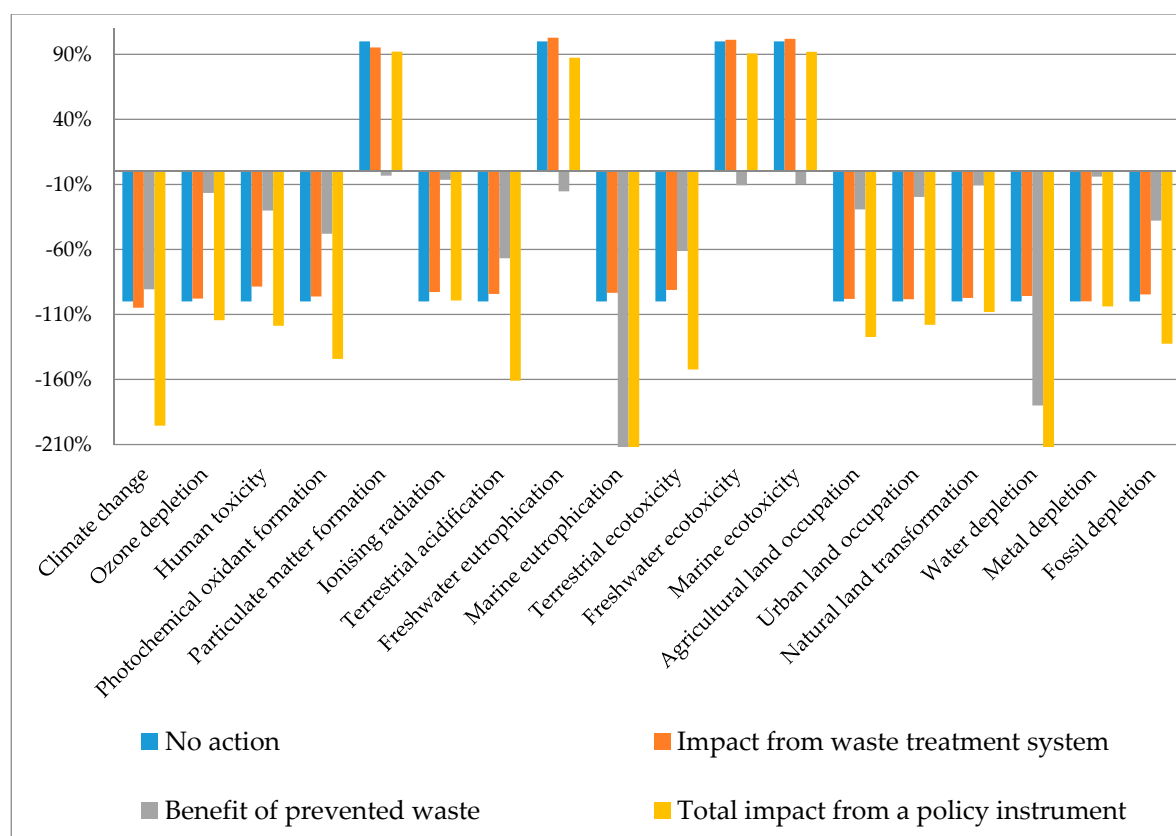


Figure S3.14. Environmental impacts of the introduction of the policy instrument “Weight based waste fee, alt 1” in comparison to the “no action” alternative (set to 100%) in Scenario 2.

The potential cumulative energy demand is presented in Figure S3.15 repeating the pattern of the Reference scenario.

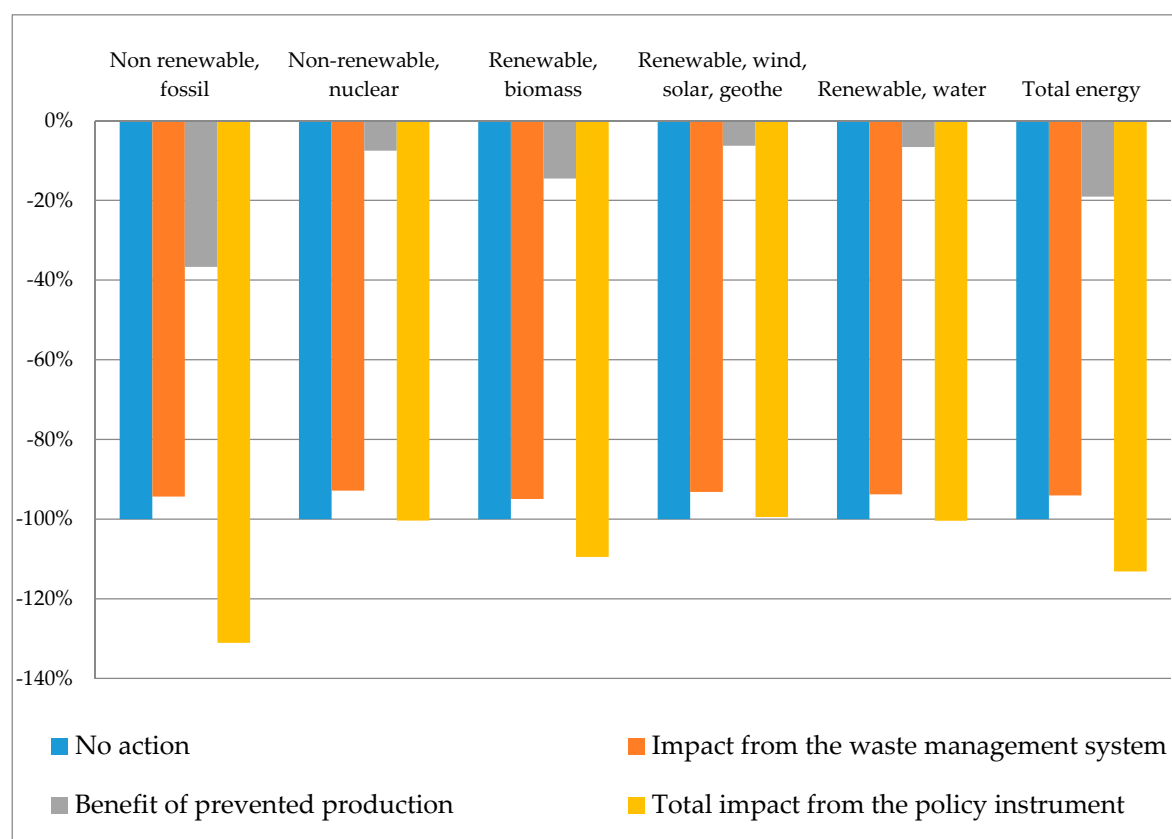


Figure S3.15. Relative Cumulative energy demand for the policy instrument “Weight based waste fee, alt. 1” in comparison to the “no action” alternative (set to 100%) in Scenario 2.

2.4. Assessment of policy instruments in Scenario 3.

The assessment results for the policy instruments Electricity certificates, Climate incineration tax and Weight based waste fee (alt. 2) in Scenario 3 are presented in Figure S3.16 and the relative Cumulative energy demand is Figure S3.17.

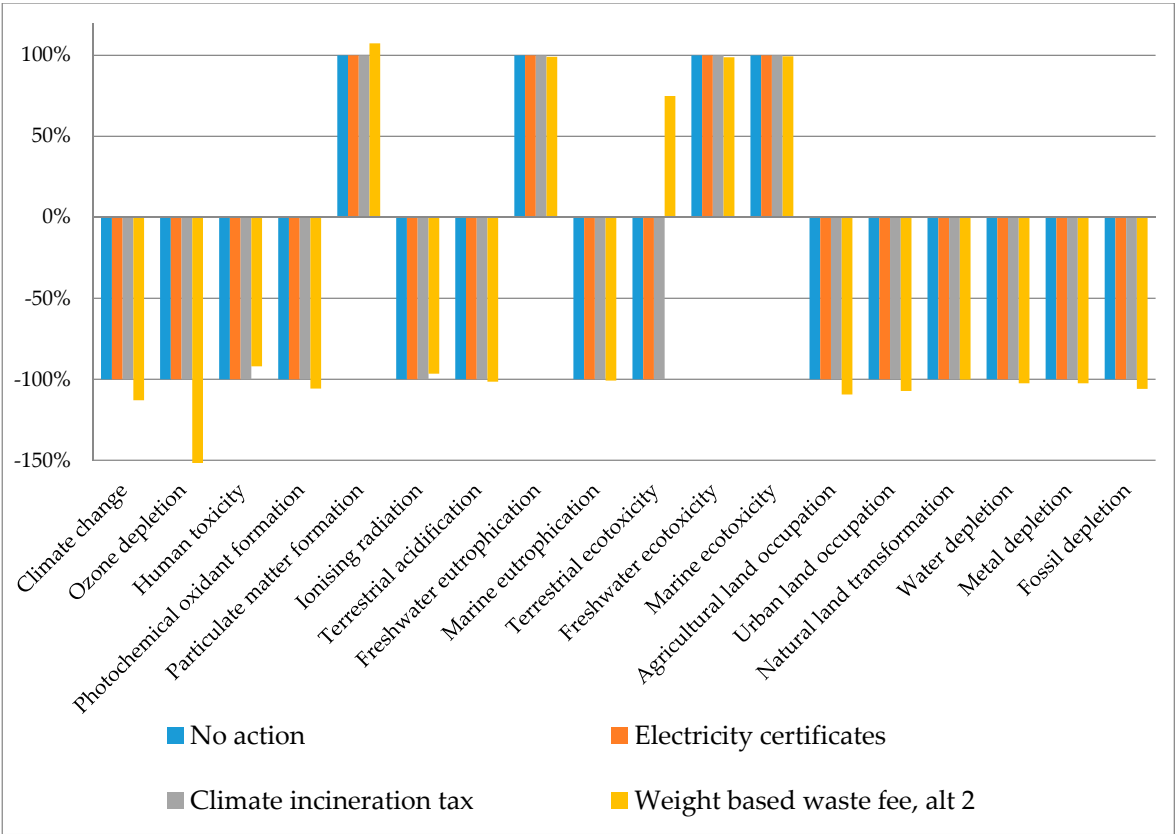


Figure S3.16. Environmental impacts of the introduction of the policy instruments in comparison to the “no action” alternative in Scenario 3.

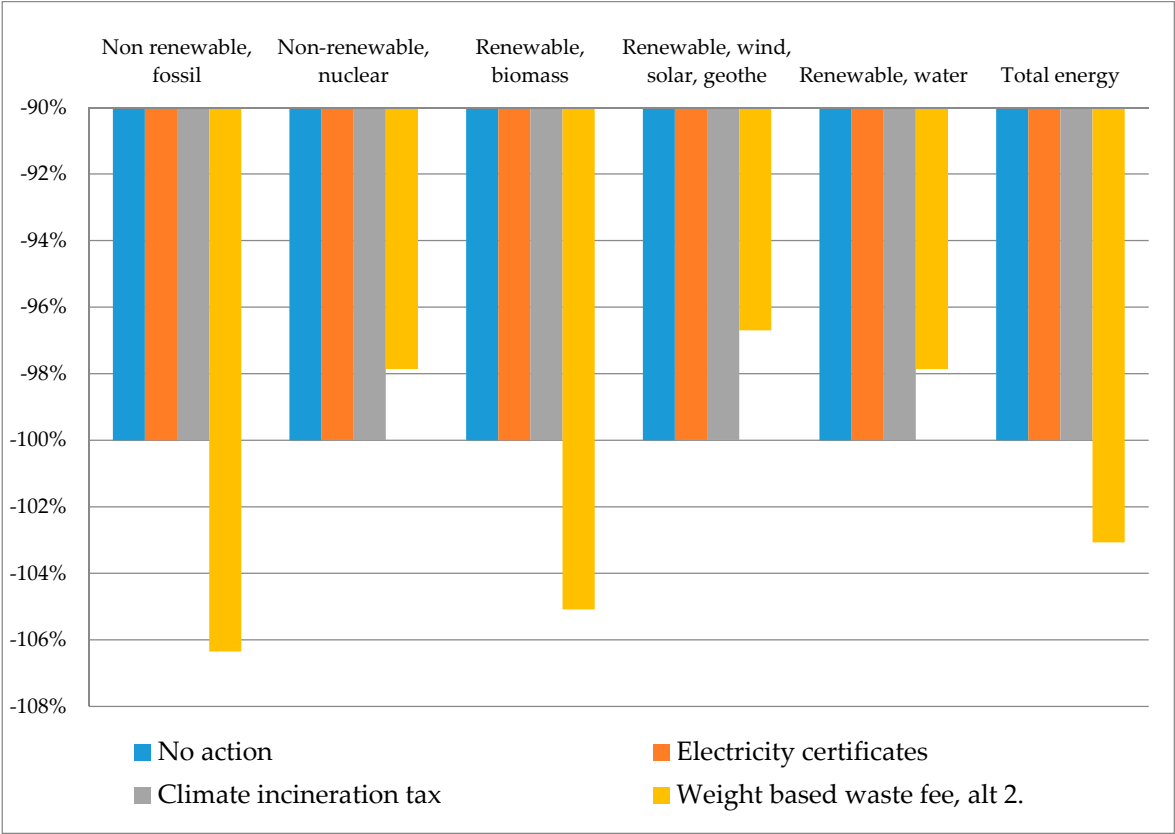


Figure S3.17. Relative Cumulative energy demand for the policy instruments in comparison to “no action” alternative set to 100% in Scenario 3.

The results for the Weight based waste fee, alt. 1, Reduction by prevention are presented Figures S3.18 and S3.19.

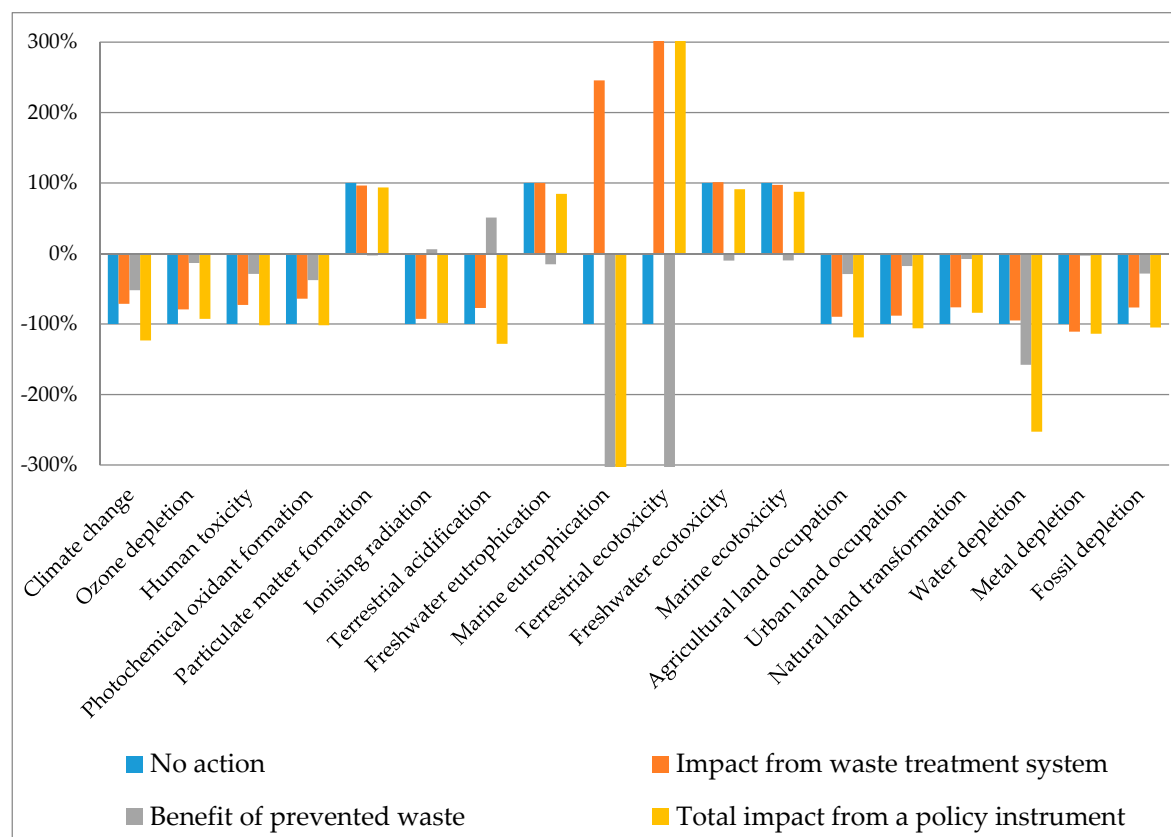


Figure S3.18. Environmental impacts of the introduction of the policy instrument “Weight based waste fee, alt. 1” in comparison to the “no action” alternative (set to 100%) in Scenario 3.

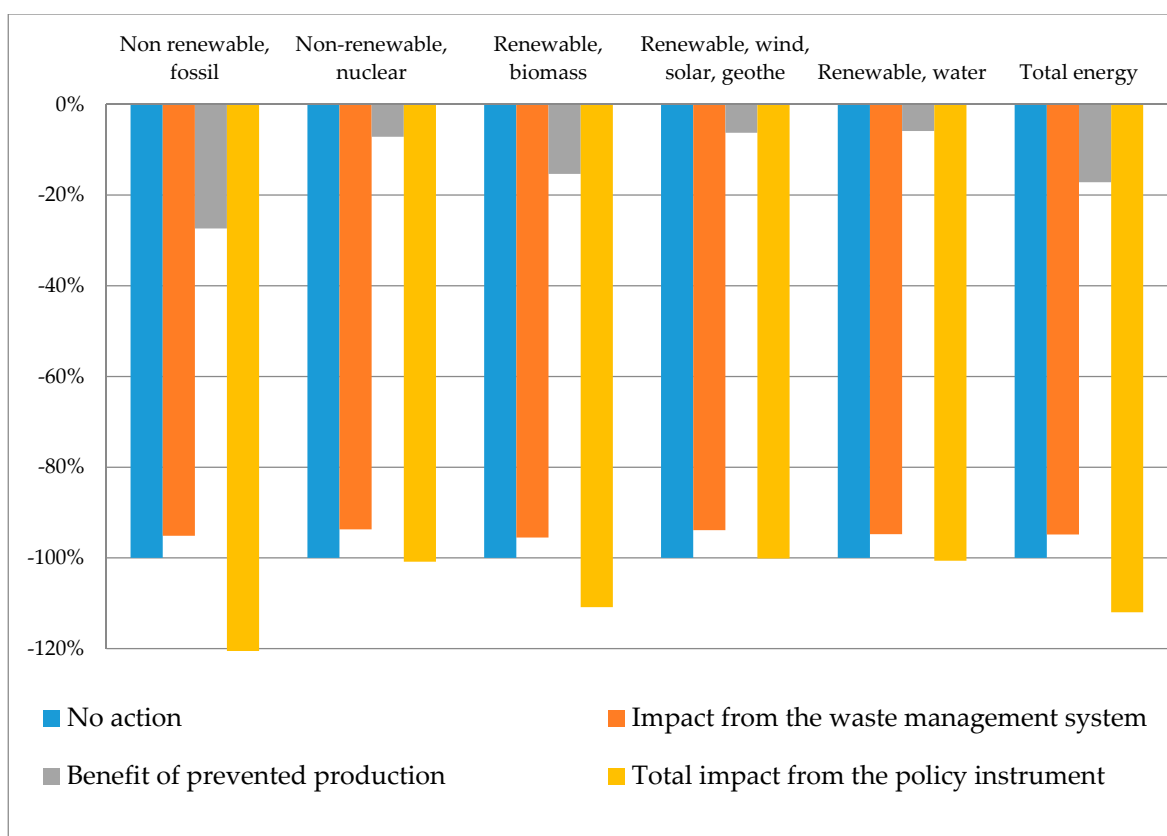


Figure S3.19. Relative Cumulative energy demand for the policy instruments “Weight based waste fee, alt. 1” in comparison to the “no action” alternative (set to 100%) in Scenario 3.

2.5. Assessment of Policy Instruments in Scenario 4.

The results for the policy instruments Electricity certificates, Climate incineration tax and Weight based waste fee (alt. 2) are presented in Figure S3.20 and S3.21.

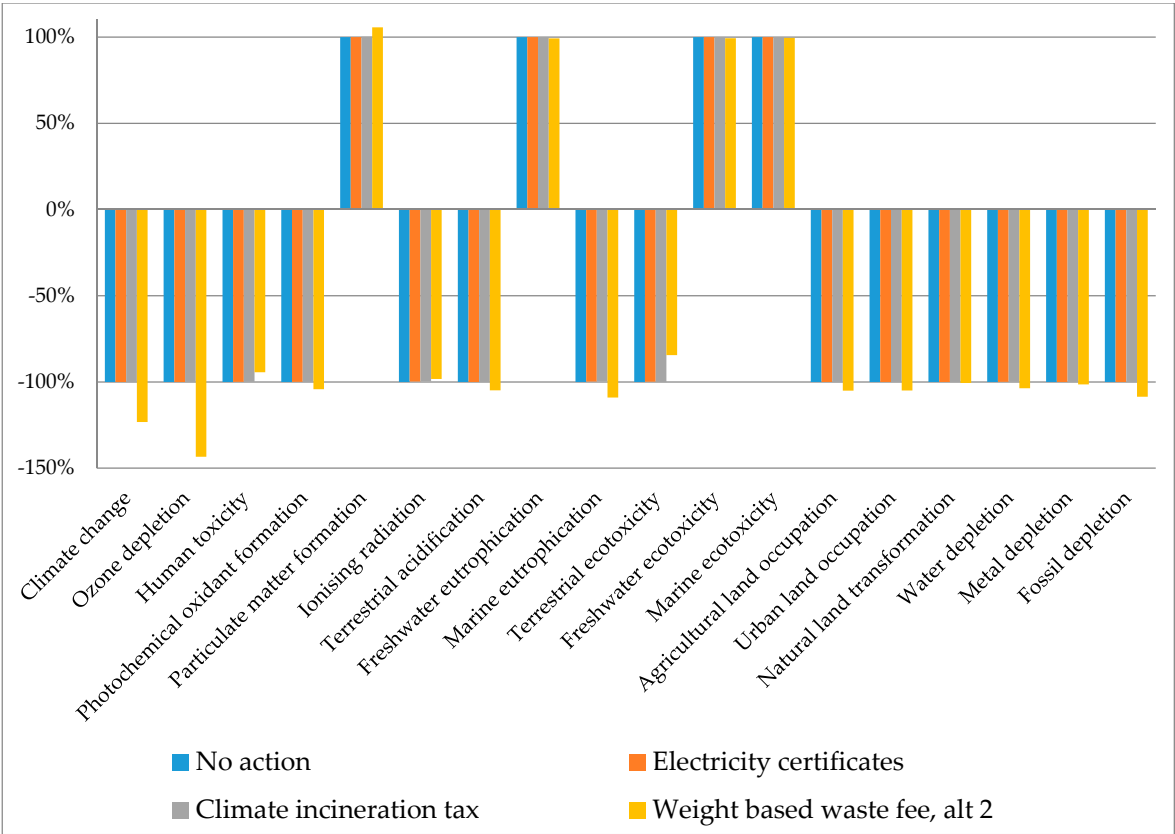


Figure S3.20. Environmental impacts of the introduction of the policy instruments in comparison to the “no action” alternative in Scenario 4.



Figure S3.21. Relative Cumulative energy demand for the policy instruments in comparison to “no action” alternative set to 100% in Scenario 4.

The results for Weight based waste fee, alt. 1, Reduction by prevention are presented in Figures S3.22 and S3.23.

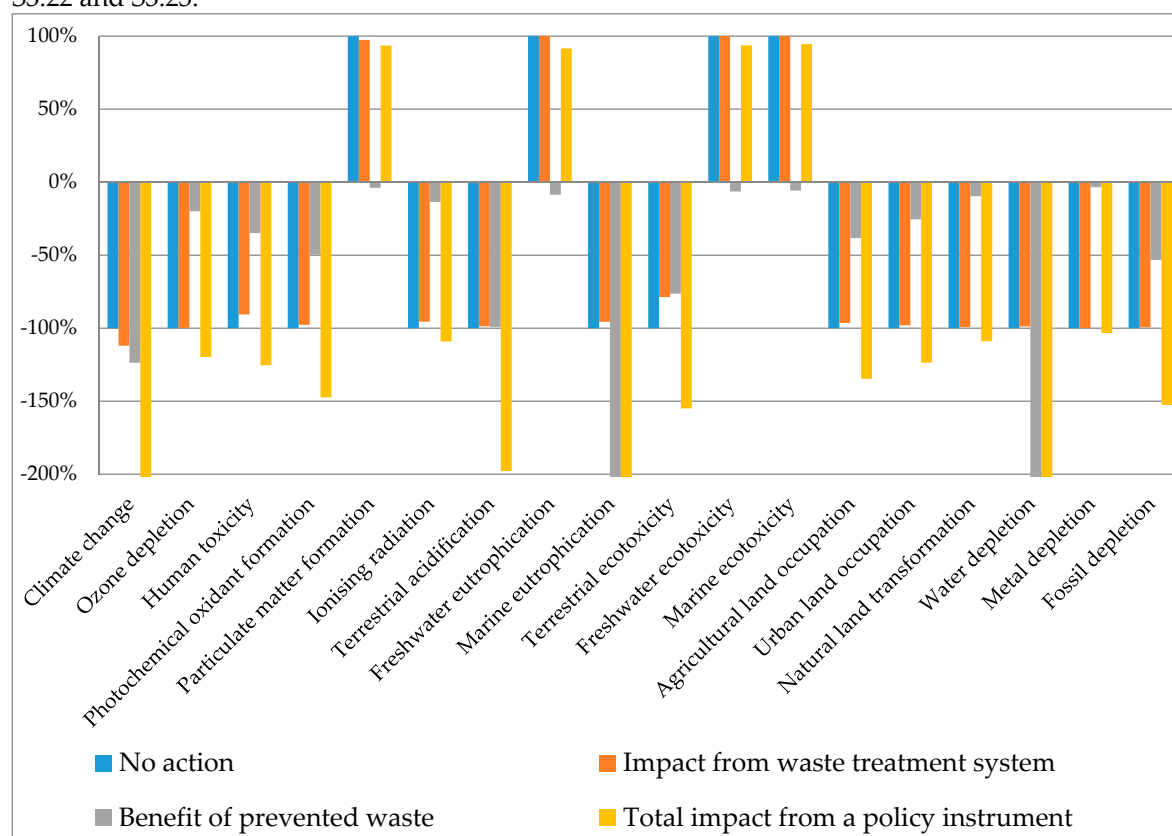


Figure S3.22. Environmental impacts of the introduction of the policy instrument “Weight based waste fee, alt. 1” in comparison to the “no action” alternative (set to 100%) in Scenario 4.

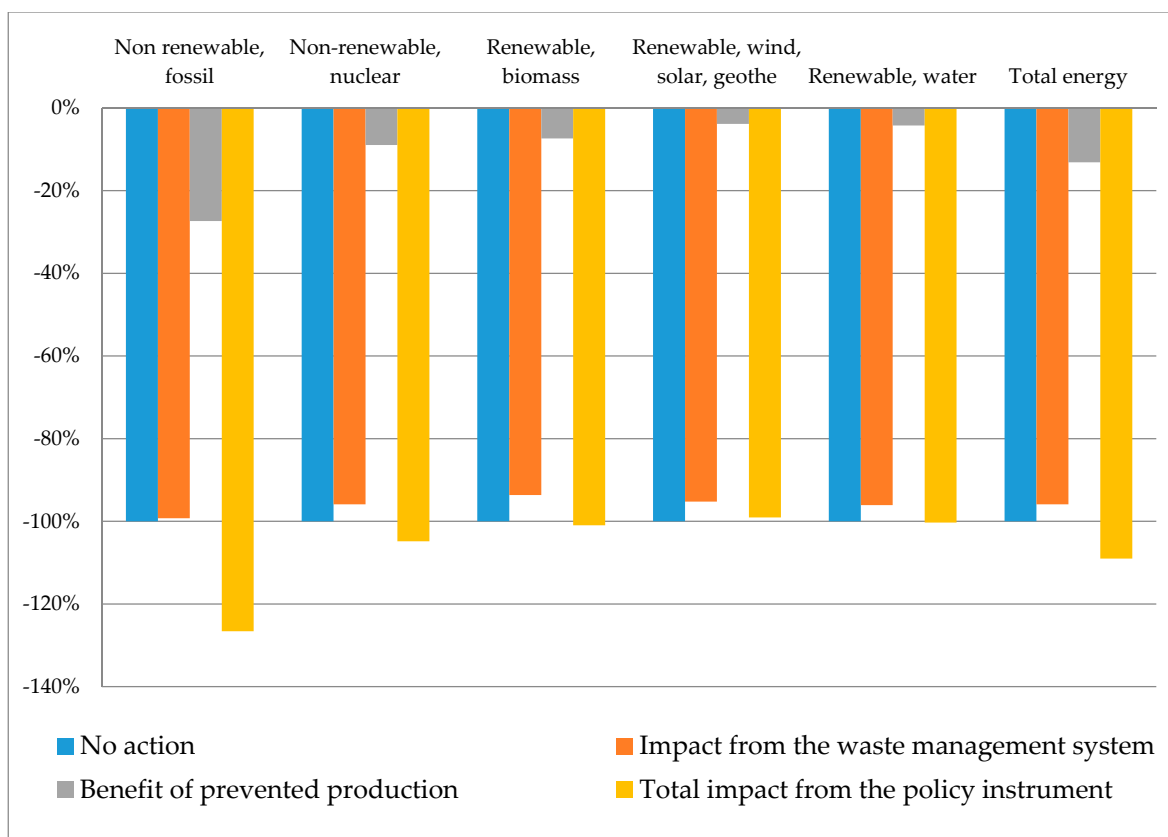


Figure S3.23. Relative Cumulative energy demand of the introduction of the policy instrument “Weight based waste fee, alt 1” in comparison to the “no action” alternative (set to 100%) in Scenario 4.

3. Policy Instrument Assessment, Marginal Data

3.1. “No Action” Alternative within Scenarios

The environmental impacts in case of various scenarios in the “no action” alternative in case of the marginal energy use are presented in Figure S3.24. Scenarios 1 to 4 are compared to the Reference scenario, which is set to 100%. The pattern of the impacts distribution is the same as for the “no action” alternative with average energy applied with a different magnitude of change.

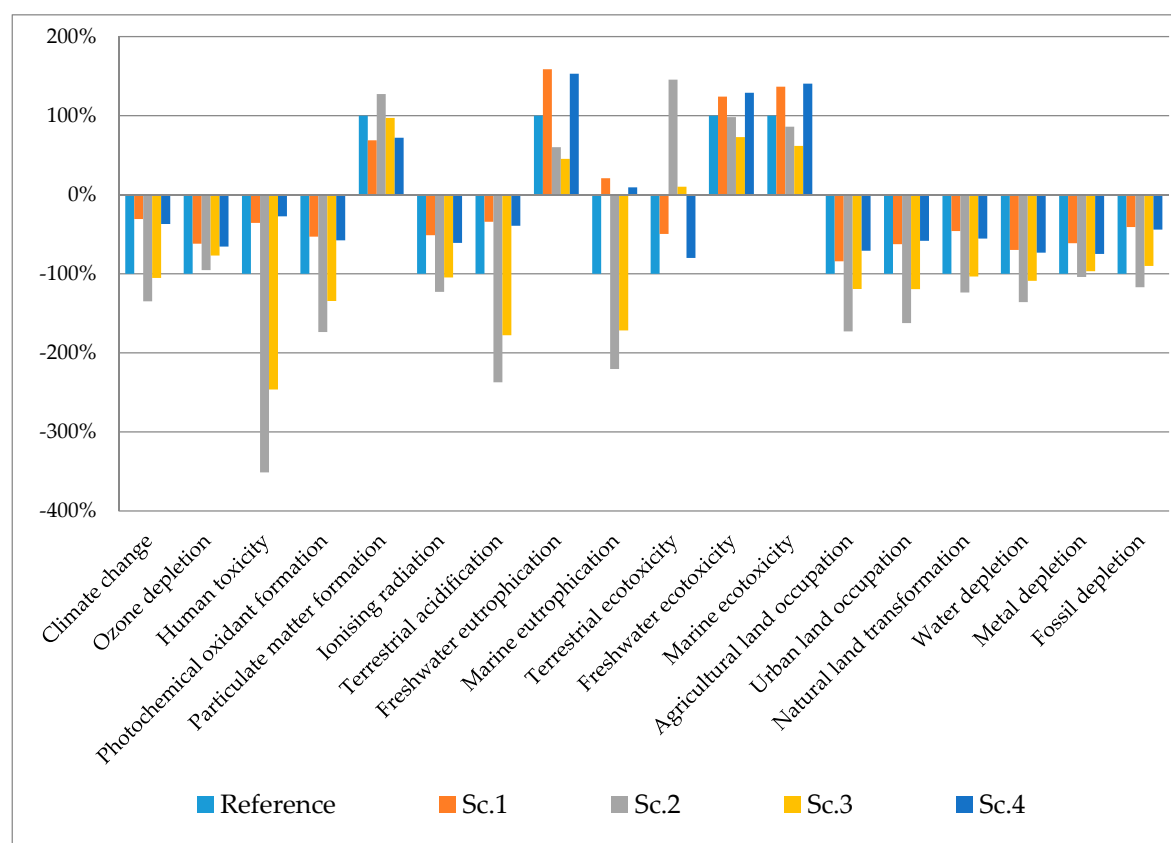


Figure S3.24. Relative environmental impacts of the different scenarios with marginal data.

The results for the assessment of the policy instruments Electricity certificates, climate incineration tax and weight based waste fee alt. 2 (increased source separation) and alt. 1 (increased waste prevention) in the Reference Scenario using marginal data are presented in Figures S3.25 and S3.26. The results are similar as with average data. The results for the assessment of the policy instruments in Scenarios 1 to 4 using marginal data are presented in Figures S3.27–S3.34.

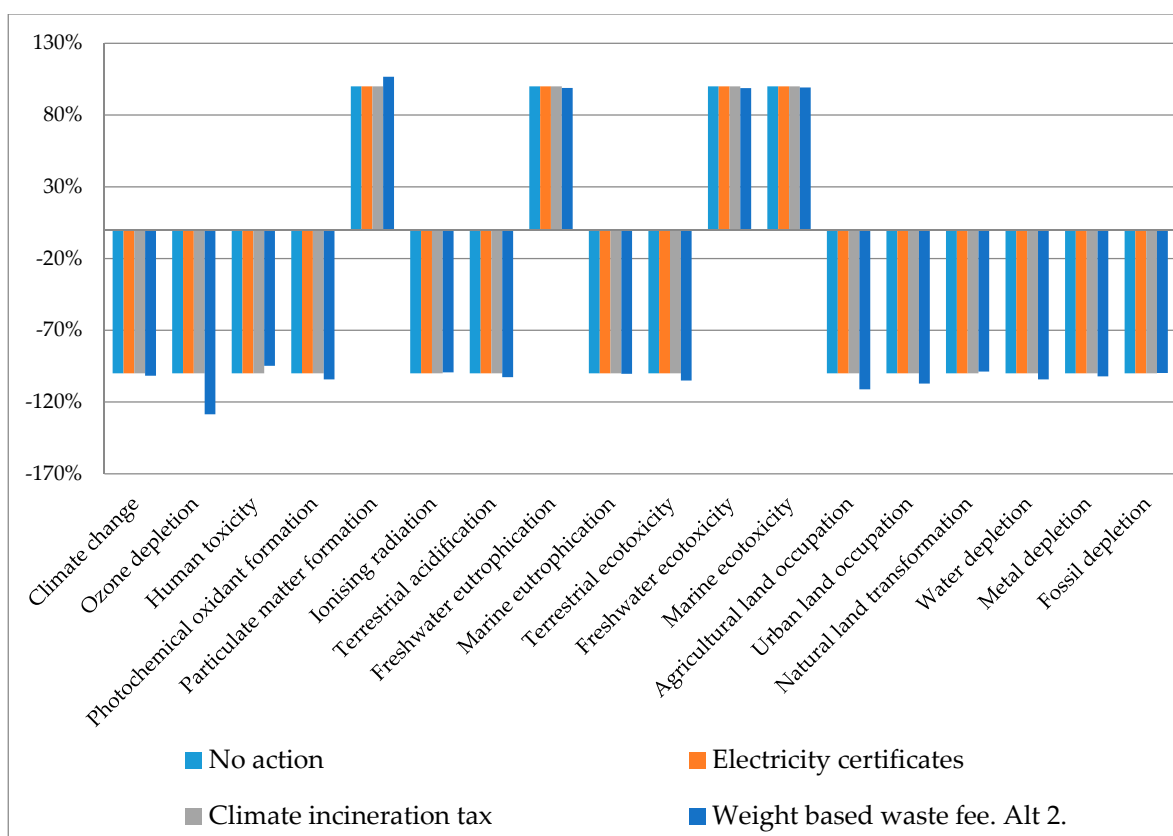


Figure S3.25. Environmental impacts of the introduction of the policy instruments in comparison to the “no action” alternative in the Reference Scenario using marginal data.

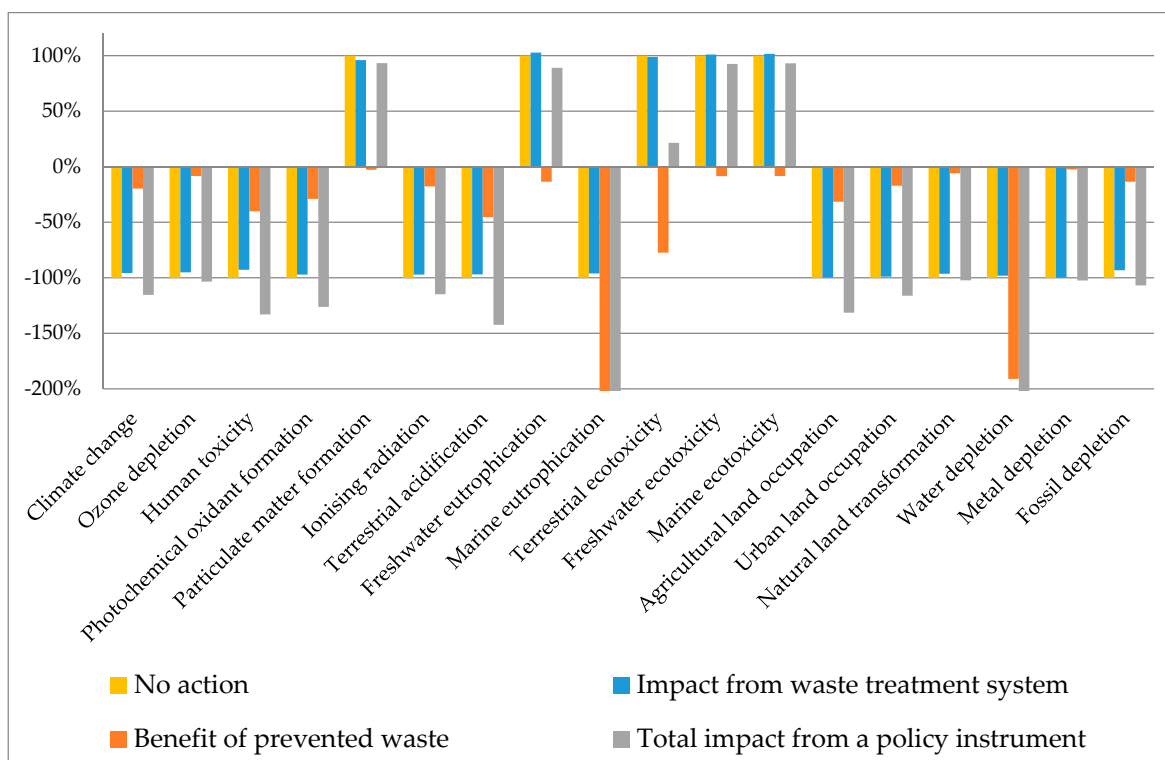


Figure S3.26. Environmental impacts of the introduction of the policy instrument “Weight based waste fee, alt. 1” in comparison to the “no action” alternative using marginal data in the Reference Scenario.

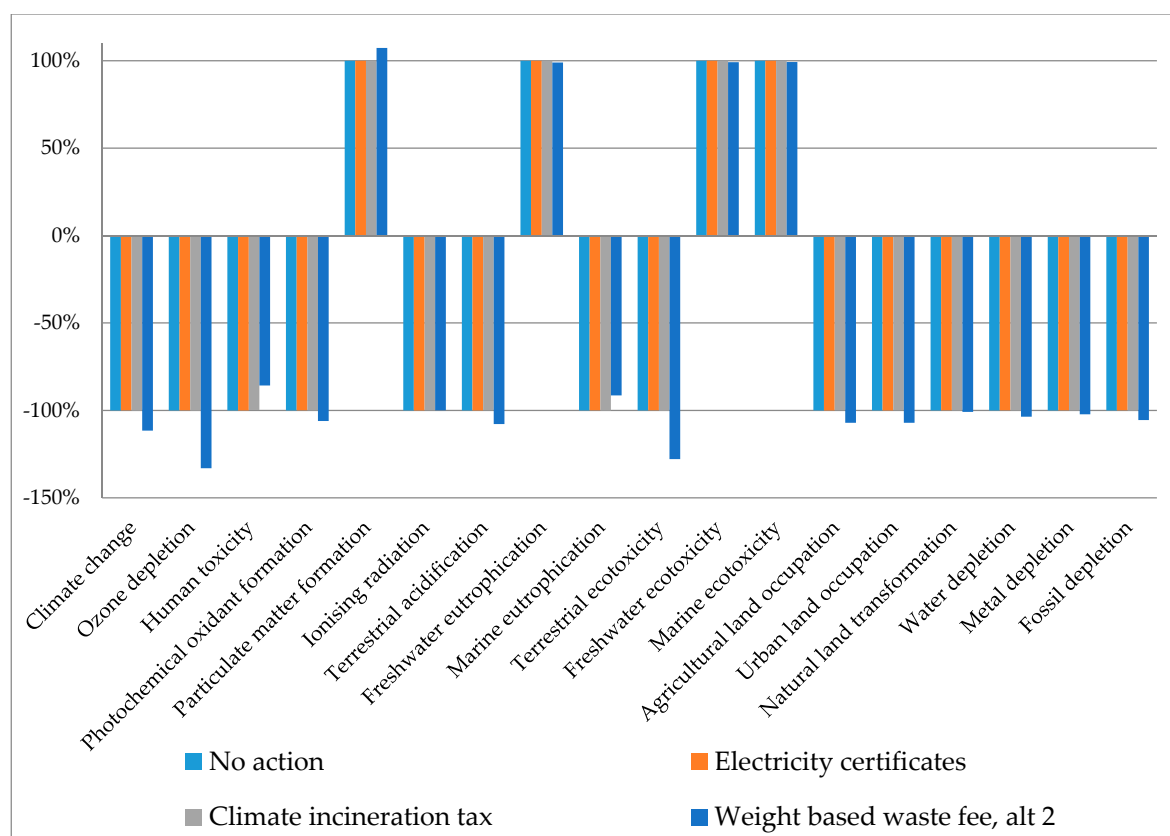


Figure S3.27. Environmental impacts of the introduction of the policy instruments in comparison to the “no action” alternative in Scenario 1 using marginal data.

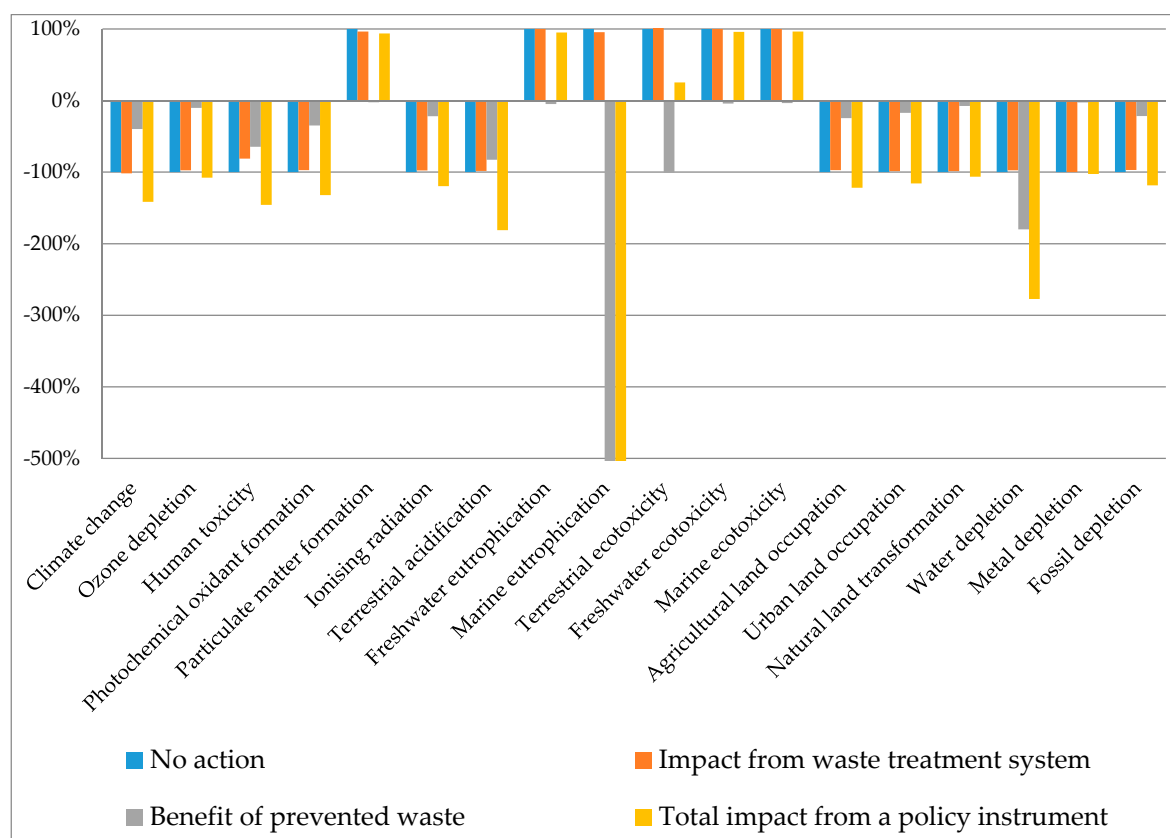


Figure S3.28. Environmental impacts of the introduction of the policy instrument “Weight based waste fee, alt. 1” in comparison to the “no action” alternative in Scenario 1 using marginal data.

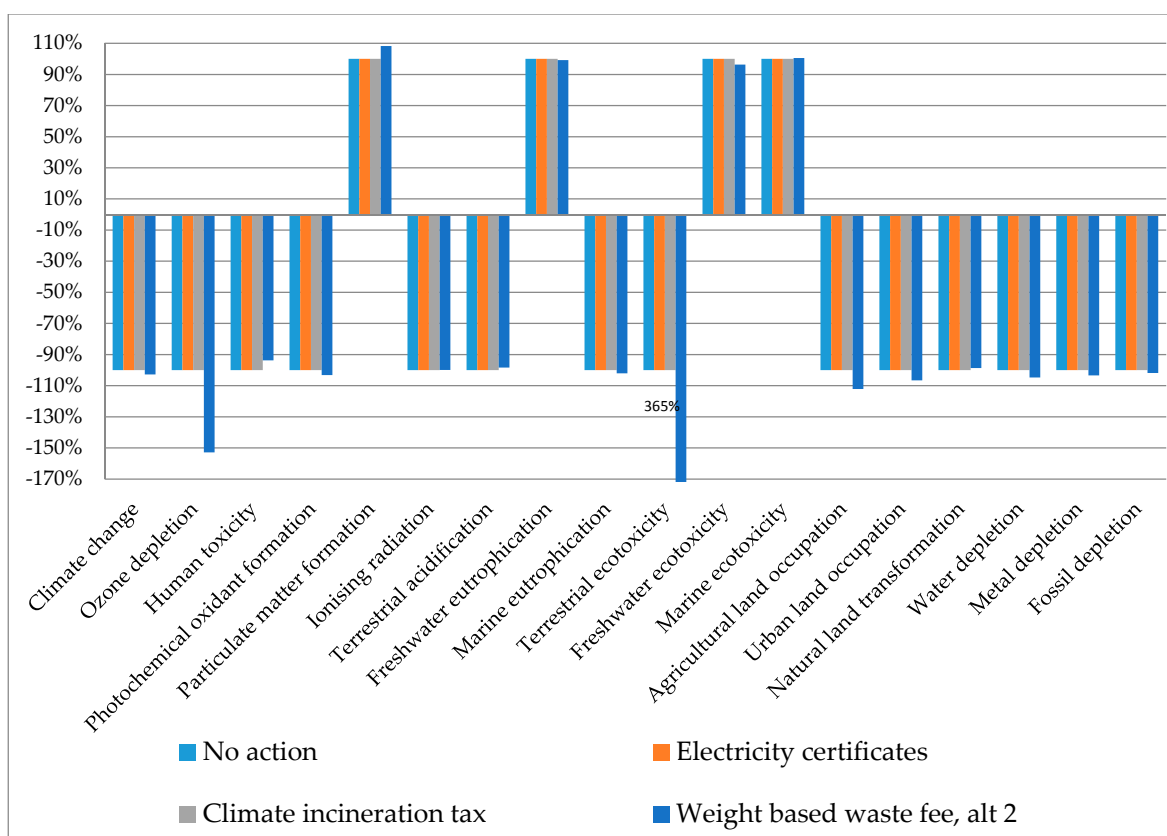


Figure S3.29. Environmental impacts of the introduction of the policy instruments in comparison to the “no action” alternative in Scenario 2 using marginal data.

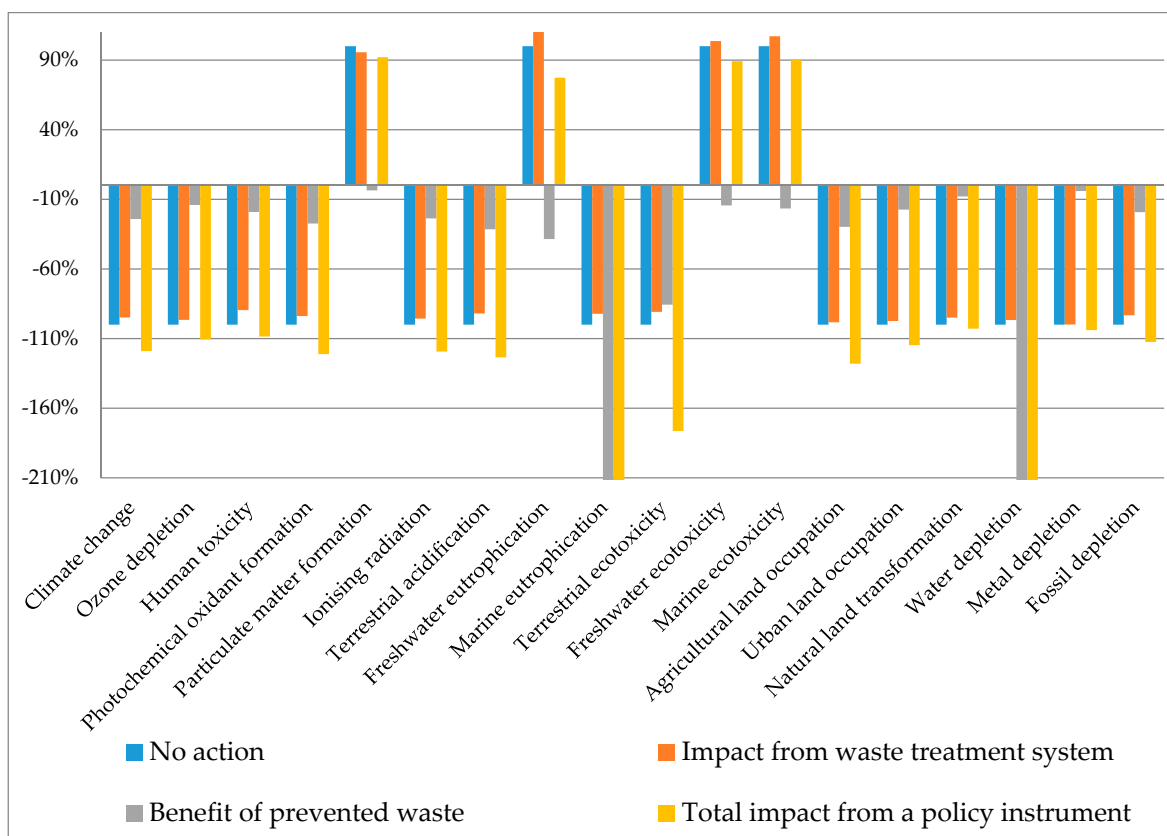


Figure S3.30. Environmental impacts of the introduction of the policy instrument “Weight based waste fee, alt. 1” in comparison to the “no action” alternative in Scenario 2 using marginal data.

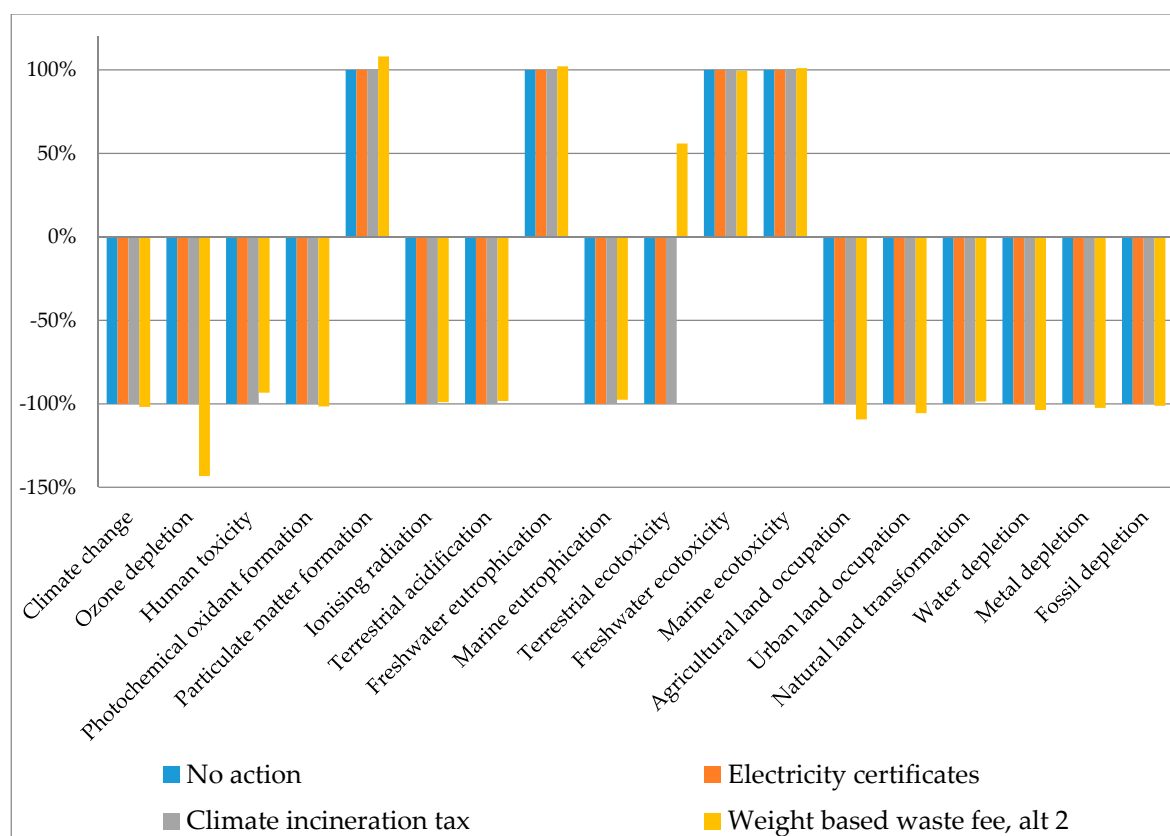


Figure S3.31. Environmental impacts of the introduction of the policy instruments in comparison to the “no action” alternative in Scenario 3.

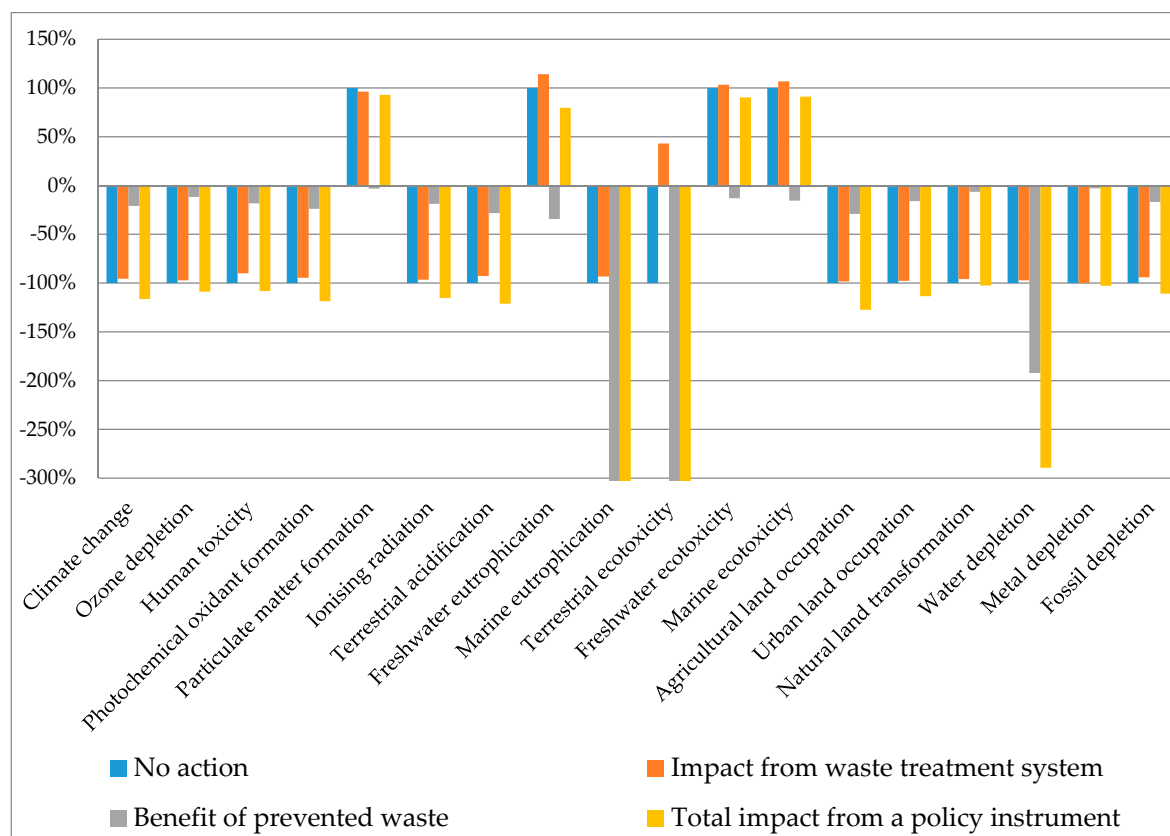


Figure S3.32. Environmental impacts of the introduction of the policy instrument “Weight based waste fee, alt. 1” in comparison to the “no action” alternative in Scenario 3 using marginal data.

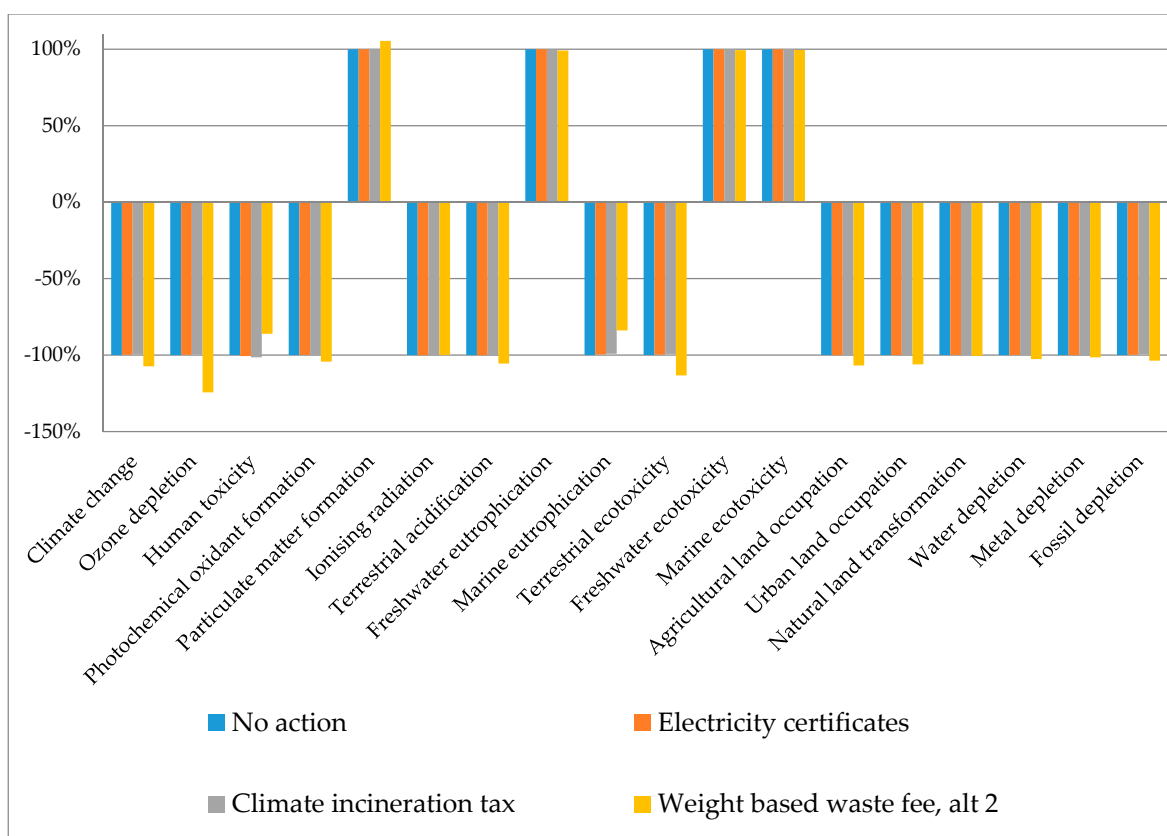


Figure S3.33. Environmental impacts of the introduction of the policy instruments in comparison to the “no action” alternative in Scenario 4 using marginal data.

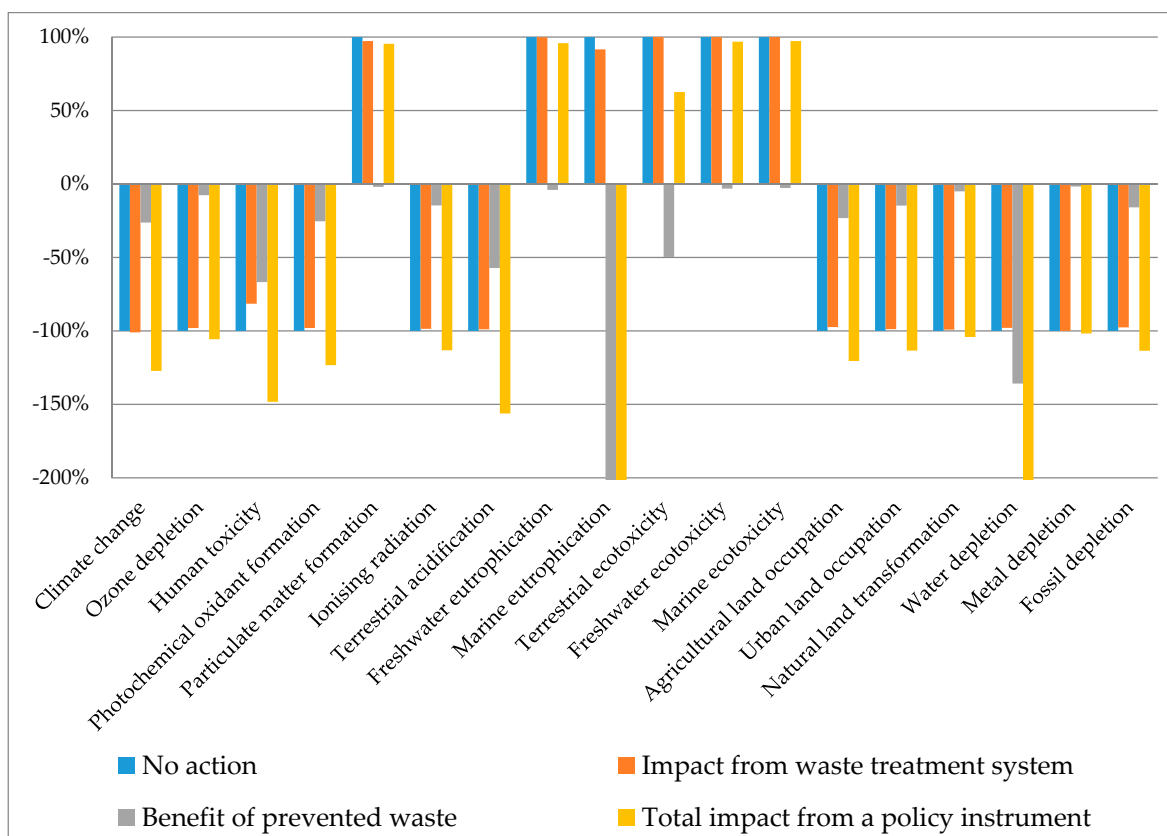


Figure S3.34. Environmental impacts of the introduction of the policy instrument “Weight based waste fee, alt. 1” in comparison to the “no action” alternative in Scenario 4 using marginal data.

References

1. Sköldbberg, H.; Unger, T. *Effekter av Förändrad Elanvändning Elproduktion: Modellberäkningar*; Elforsk: Stockholm, Sweden, 2008.
2. Forsfält, T. Samhällsekonomiska effekter av två styrmedel för minskade avfallsmängder. Available online: <http://www.konj.se/publikationer/special-studier/specialstudier/2011-05-27-samhallsekonomiska-effekter-av-tva-styrmedel-for-minskade-avfallsmangder.html> (accessed on 27 May 2011).