

Supplementary Information

Table of contents

Supplementary Figure 1. Evolution of the energy-efficiency index, emissions factor (Mt CO₂/EJ) and energy prices (% change compared to 2018) until 2050.

Supplementary Figure 2. Evolution of energy-service prices.

Supplementary Figure 3. Changes in carbon and waste footprints by consumption category relative to the Reference.

Supplementary Figure 4. Use rate of owned energy-using goods by households and use rate of energy-using goods of the PSS sector.

Supplementary Figure 5. Share of market-provided energy services in total energy-service spending in 2050.

Supplementary Figure 6. The trilemma – Waste footprint.

Supplementary Figure 7. Schematic representation of CIRCEE-LIFE.

Supplementary Figure 8. PSS ownership structure in CIRCEE.

Supplementary Figure 9. Sensitivity of behavioural modifiers to the substitution elasticity between home- and market-provided energy services across lifestyle groups and lifestyle drivers.

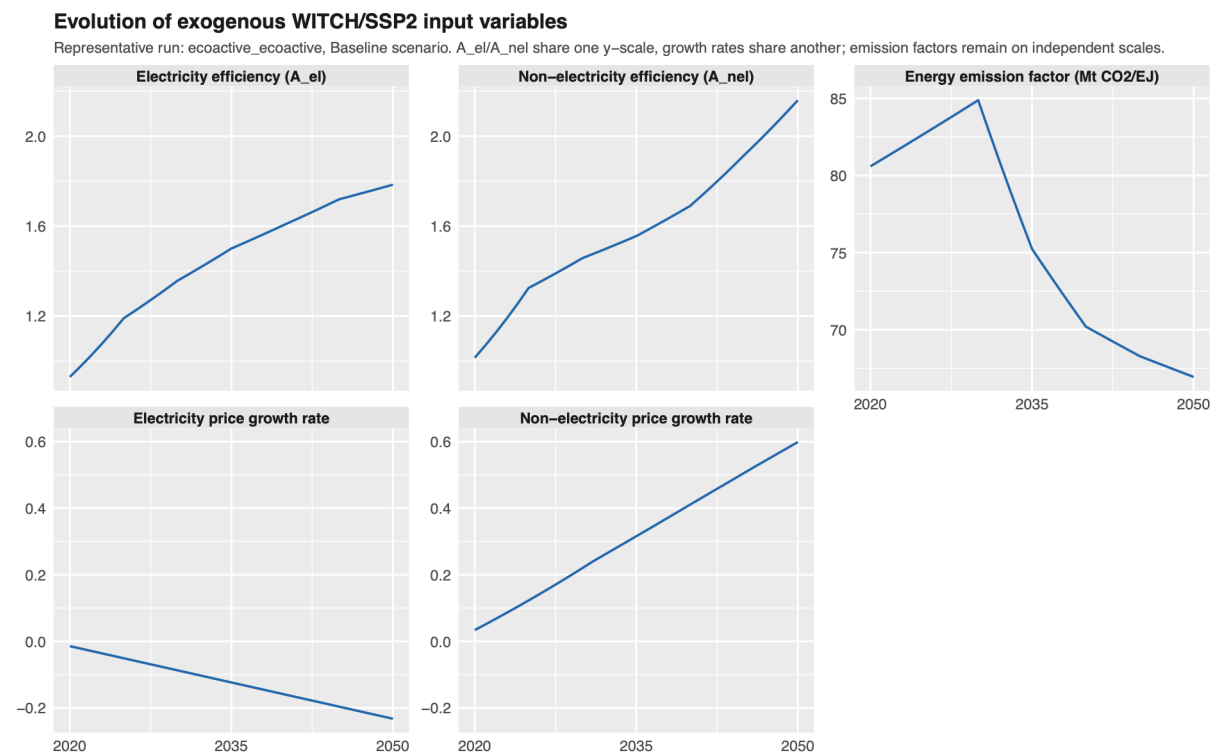
Supplementary Figure 10. Sensitivity analysis of Refuse and Rethink outcomes.

Supplementary Figure 11. Sensitivity analysis of environmental footprints.

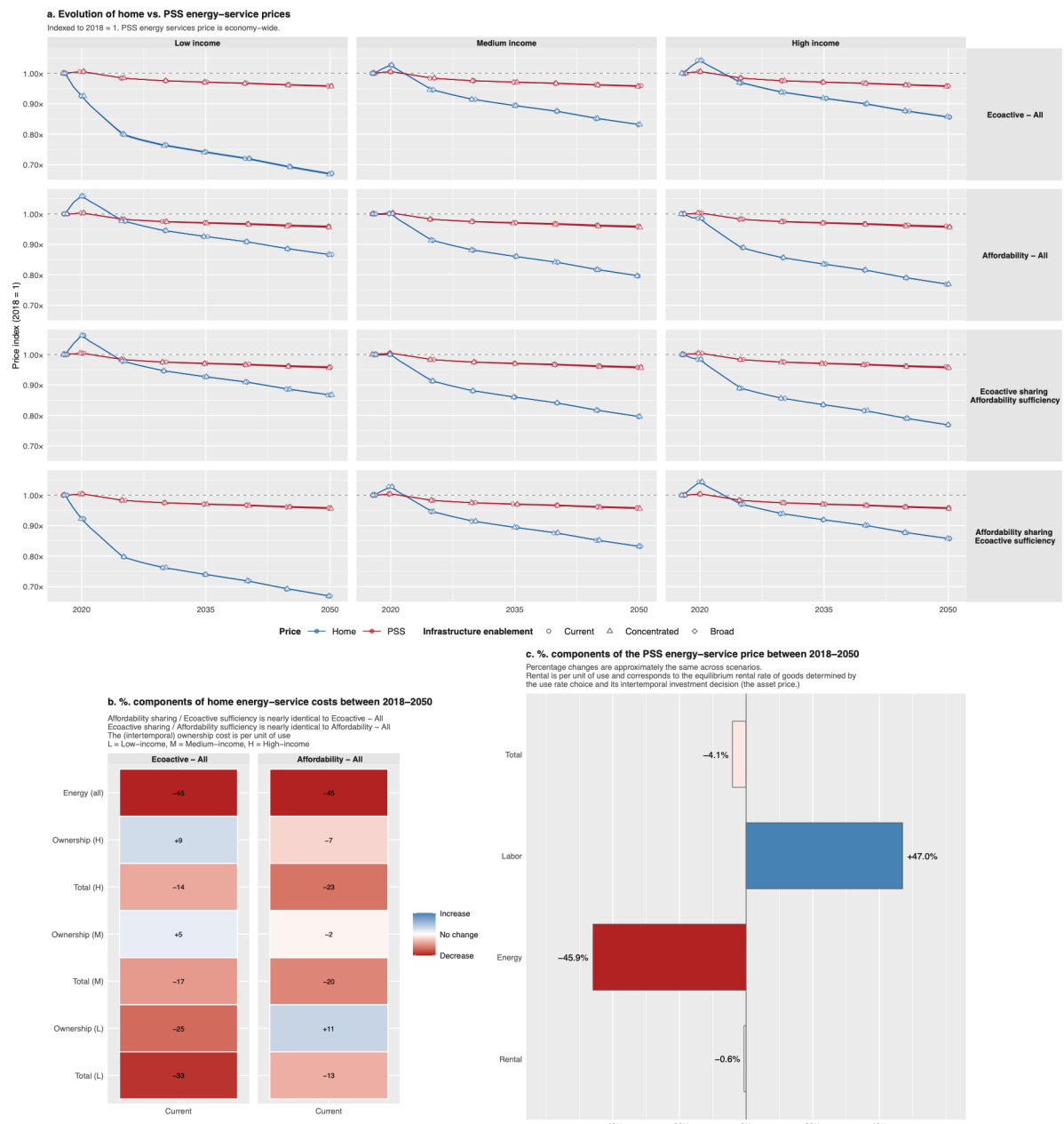
Supplementary Figure 12. Sensitivity analysis of macro-level environmental outcomes.

Supplementary Figure 13. Sensitivity analysis of distributional outcomes.

Supplementary Figure 1. Evolution of the energy-efficiency index, emissions factor (Mt CO₂/EJ) and energy prices (% change compared to 2018) until 2050. Source: WITCH-SSP2.



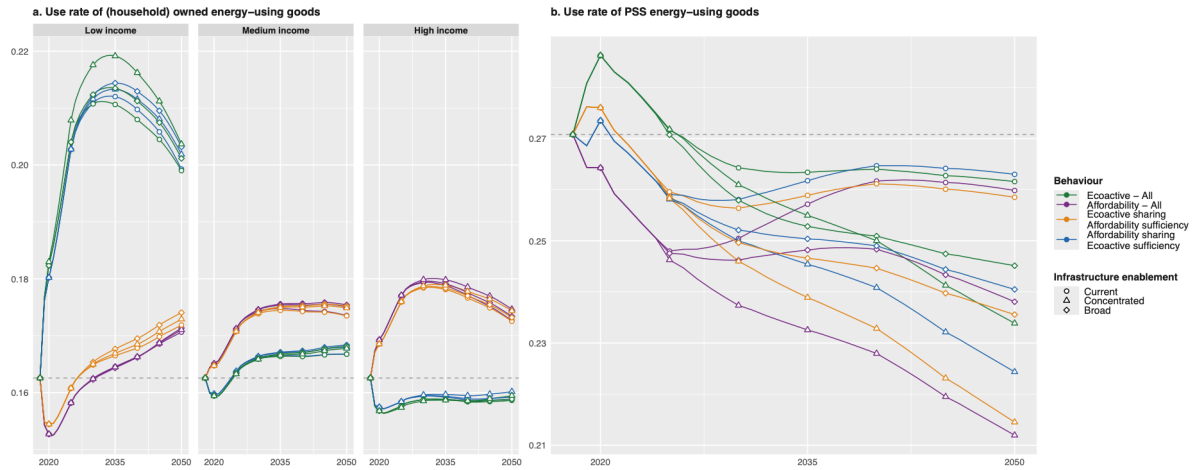
Supplementary Figure 2. Evolution of prices. (a) Home and PSS energy-service price indices, 2018–2050, indexed to 2018 = 1, by lifestyle group and lifestyle driver. The price of energy services provided by the PSS market is economy-wide and shown identically in each lifestyle group panel for comparison. (b) Percentage change in the components of home energy-service costs between 2018 and 2050 for the two lifestyle drivers Ecoactive-All and Affordability-All at Current enablement. Ownership cost is per unit of use. L, M and H denote lower-, medium-, and higher-income groups. (c) Percentage change in the components of the PSS energy-service price between 2018 and 2050, economy-wide. Rental corresponds to the equilibrium rental rate of goods, determined jointly by the use-rate choice and the intertemporal investment decision. Source: CIRCEE-LIFE runs.



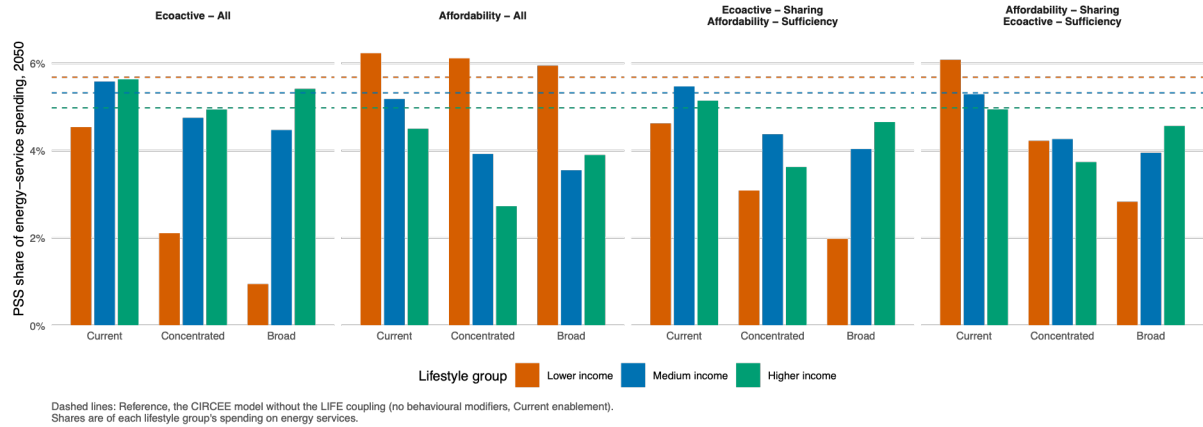
Supplementary Figure 3. Changes in carbon and waste footprints by consumption category relative to the Reference. Source: CIRCEE-LIFE runs.



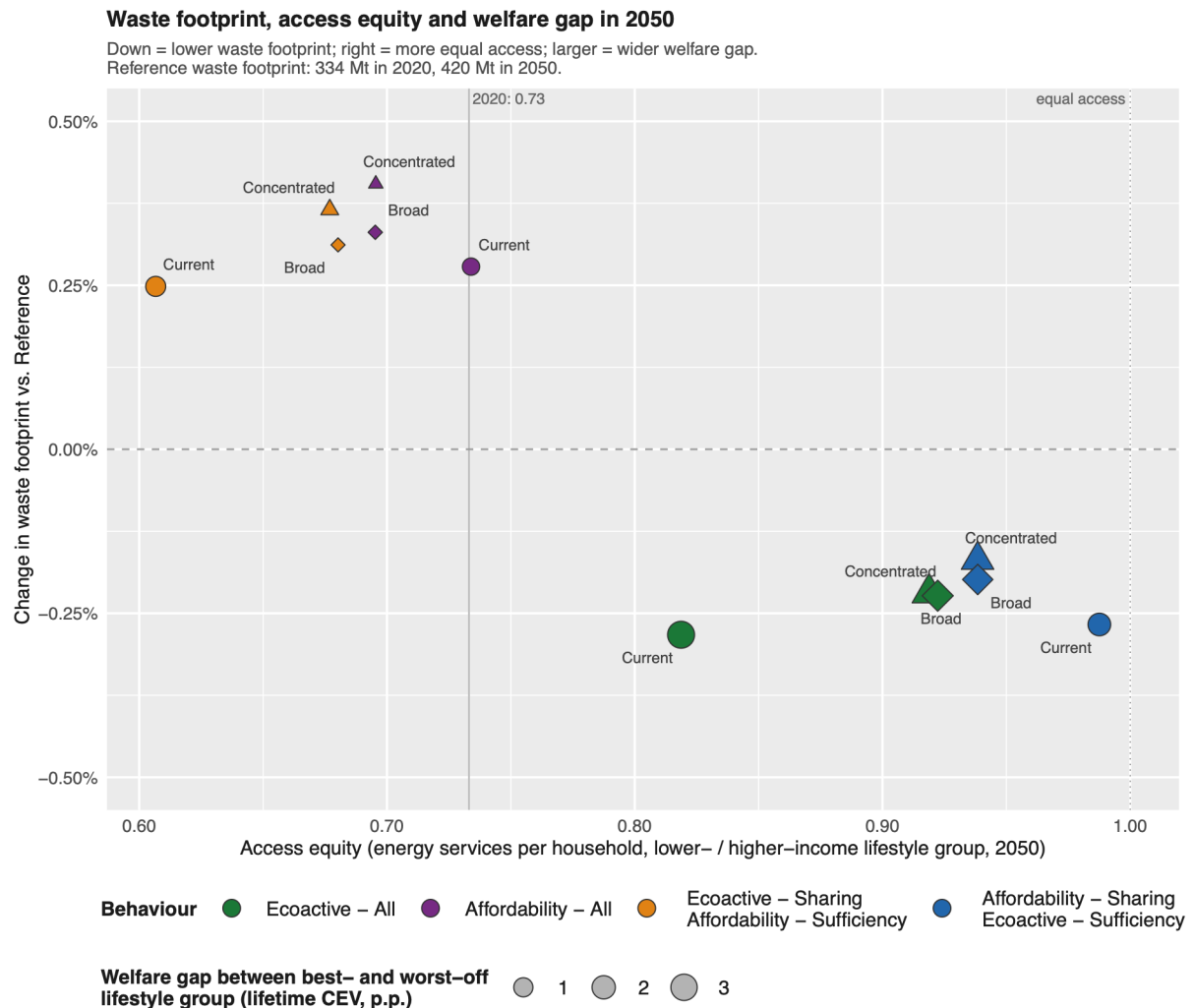
Supplementary Figure 4. Use rate of owned energy-using goods by households and use rate of energy-using goods of the PSS sector. (a) Use rate of household-owned energy-using goods, 2018–2050, by lifestyle group, lifestyle driver and infrastructure setting. The dashed line marks the 2018 reference level for each lifestyle group. (b) Use rate of energy-using goods used by the PSS sector, economy-wide, over the same period, using the same visual encodings. In both panels, colour denotes lifestyle driver and shape denotes infrastructure setting (circle = Current, triangle = Concentrated, diamond = Broad). Source: CIRCEE-LIFE runs.



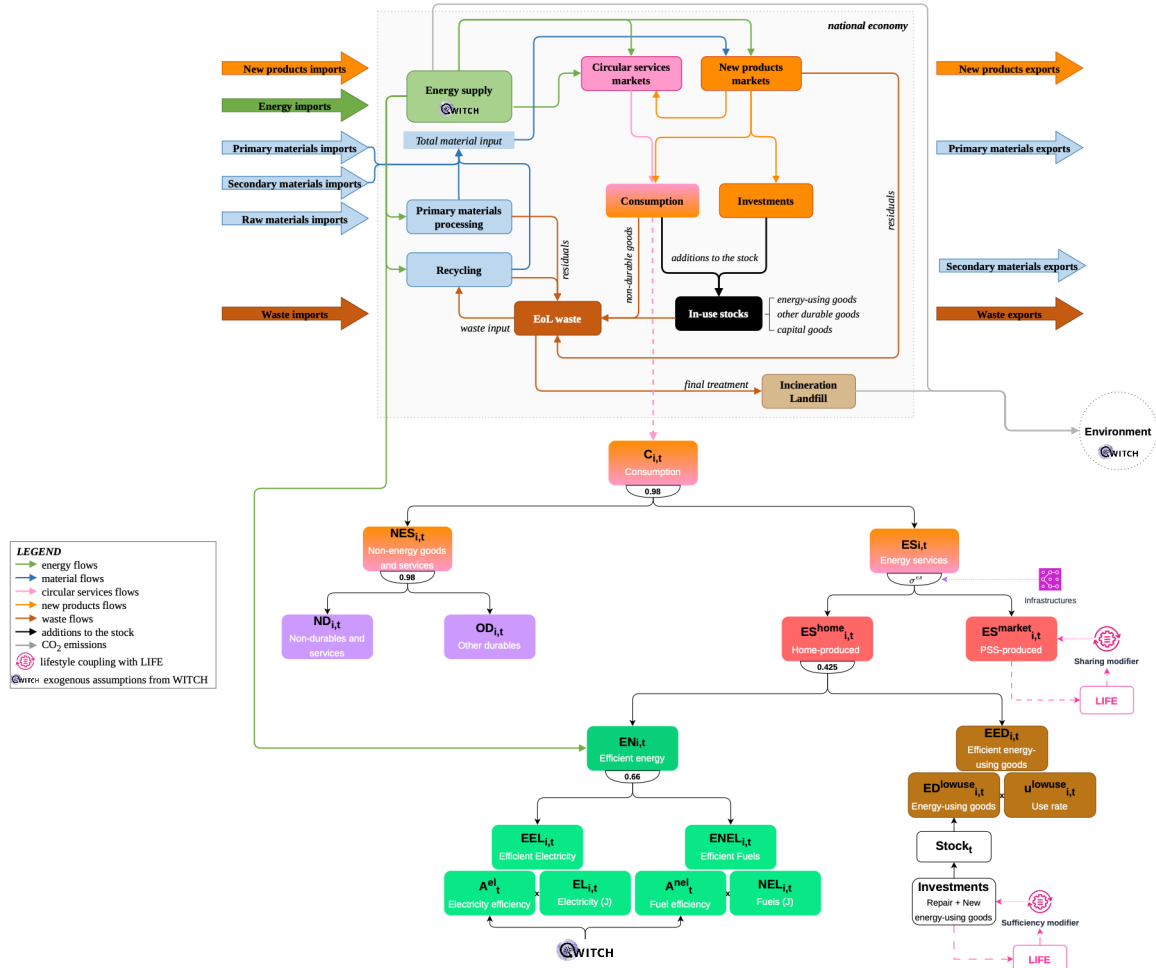
Supplementary Figure 5. Share of market-provided energy services in total energy-service spending in 2050. Bars show the share of each lifestyle group's spending on energy services that goes to PSS, for the four lifestyle-driver combinations under Current, Concentrated and Broad enablement. Dashed lines show the Reference: the CIRCEE model without LIFE coupling, with no behavioural modifiers and Current enablement.



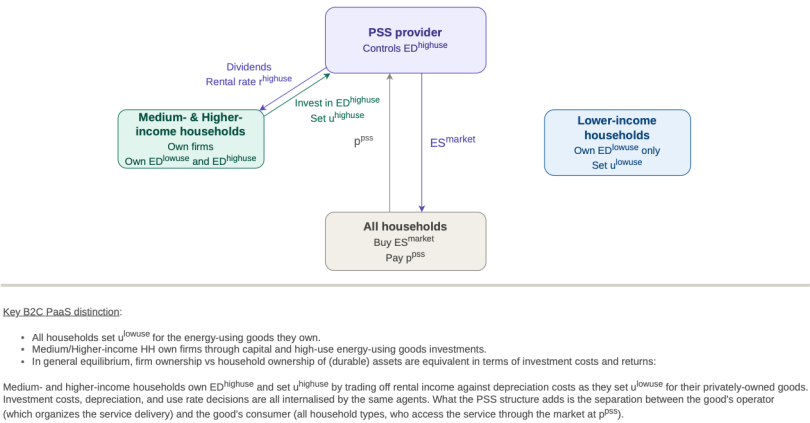
Supplementary Figure 6. Waste footprint, energy-services access equity and welfare gap in 2050. Each point represents one of the twelve scenarios formed by four lifestyle-driver combinations and three infrastructure-enablement settings in 2050. The x-axis represents access equity, the ratio of per-household energy-service consumption in the lower-income group to that in the higher-income group, where 1.0 (dotted line) is parity. The y-axis represents the economy-wide waste footprint relative to the Reference; points below the dashed line indicate a reduction. Point size shows the welfare spread: the lifetime consumption-equivalent welfare change of the best-off lifestyle group minus that of the worst-off, in percentage points. A larger point means the scenario leaves the lifestyle groups further apart. Colour denotes the lifestyle driver, and shape denotes the infrastructure setting. Source: CIRCEE-LIFE runs.



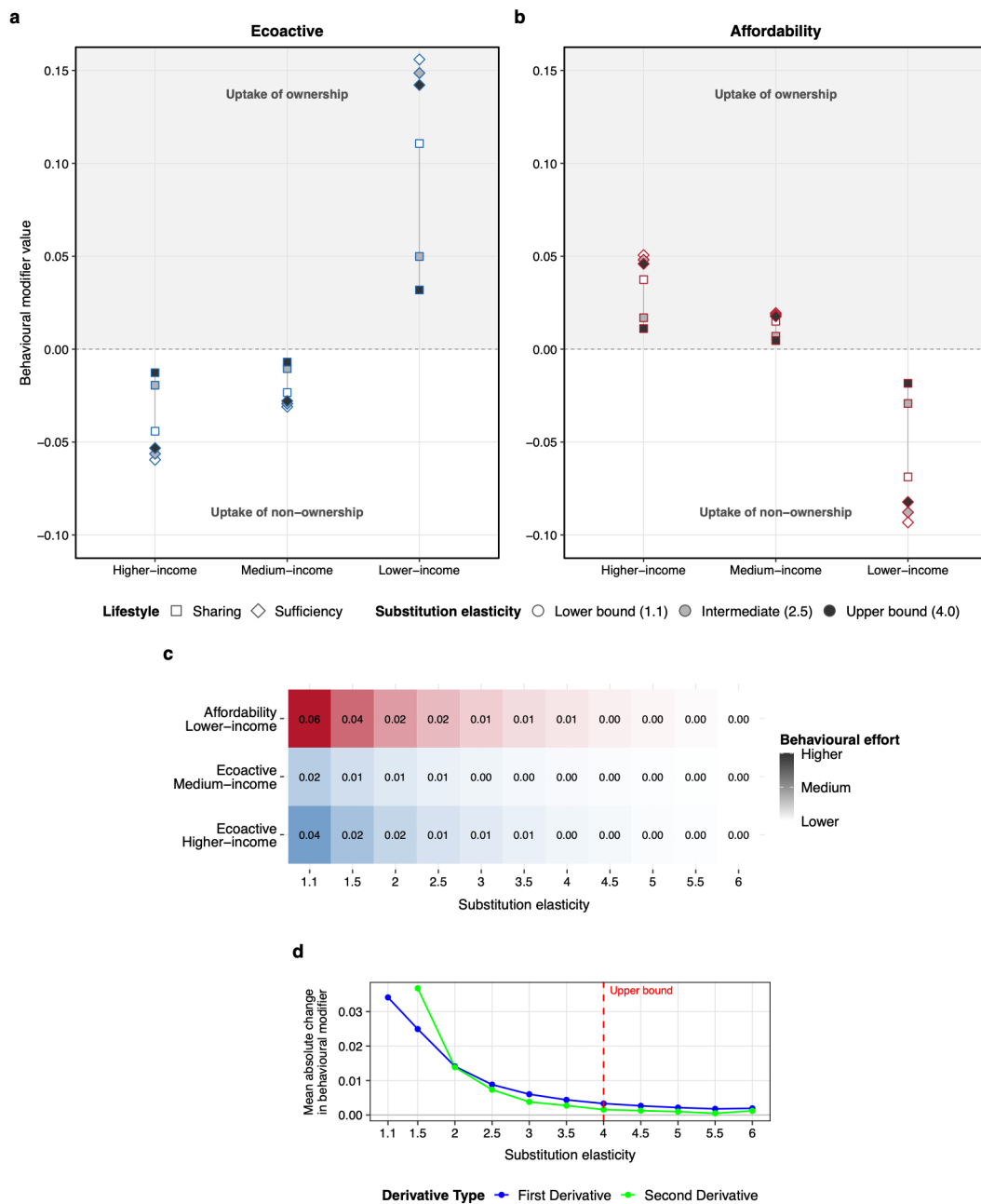
Supplementary Figure 7. Schematic representation of CIRCEE-LIFE. The economy includes (aggregate) material-processing firms, final-goods producers (non-durable, energy-using durable, other durable, and capital goods), circular services providers (market-provided energy services and repair services), a government, and three types of households differentiated by their lifestyle and income. The consumption CES nests different goods with a degree of substitutability. The stock of energy-using durable goods is shaped by sufficiency behavioural modifiers, while the relative demand for energy services provided by the PSS market is shaped by sharing behavioural modifiers.



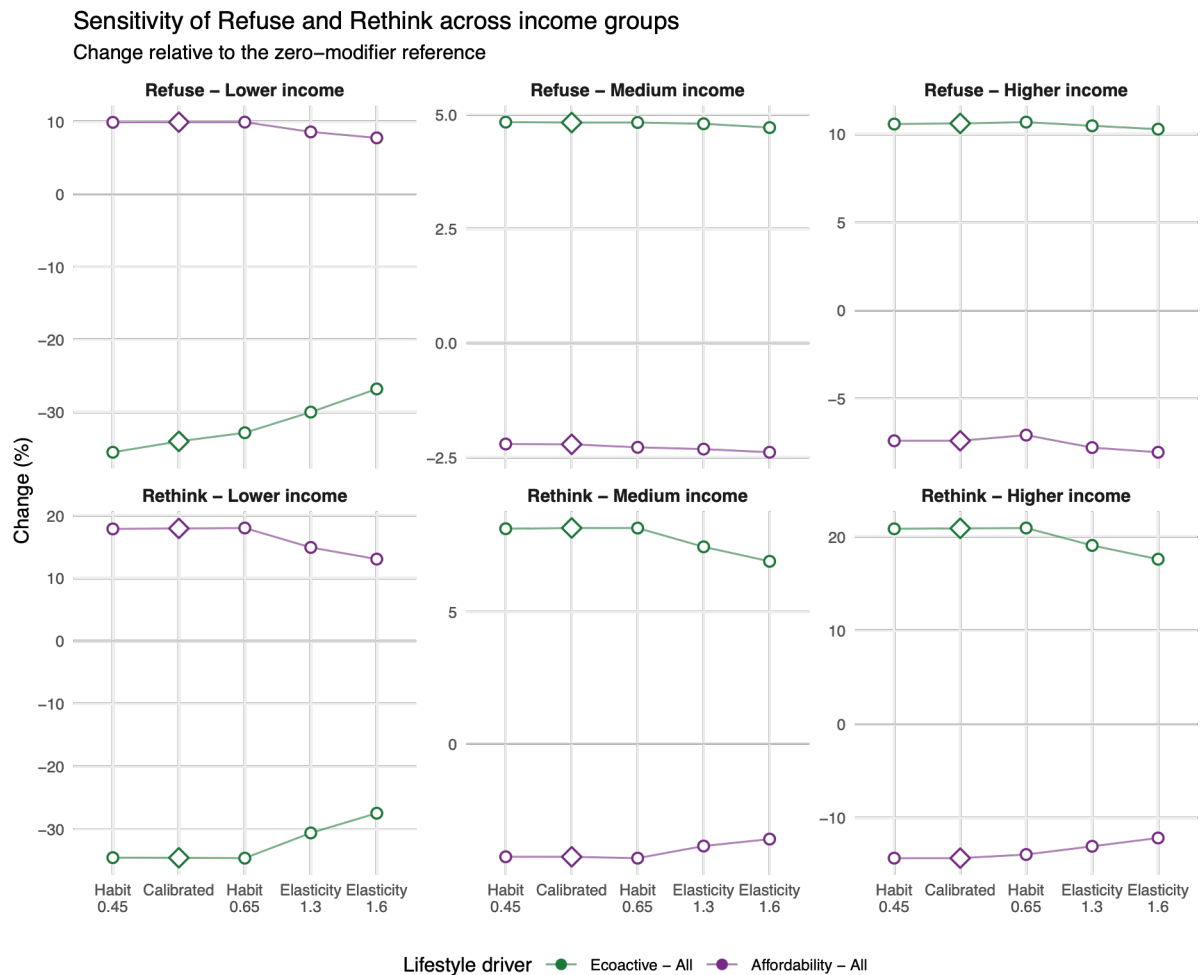
Supplementary Figure 8. PSS ownership structure in CIRCEE.



Supplementary Figure 9. Sensitivity of behavioural modifiers to the substitution elasticity between home- and market-provided energy services across lifestyle groups and lifestyle drivers. Higher substitution parameters correspond to more enabling infrastructure. Modifiers increase or decrease the uptake of sharing and sufficiency in households' continuous consumption decision equations. Positive modifiers indicate greater uptake of ownership models, whereas negative values indicate greater uptake of non-ownership models. **(a)** Behavioural modifier values at three levels of substitution elasticity (1.1, 2.5 and 4.0) for the Ecoactive scenario. The shaded region above the dashed line indicates net uptake of ownership, while the region below indicates uptake of non-ownership. **(b)** Behavioural modifier values at three levels of substitution elasticity (1.1, 2.5 and 4.0) for the Affordability scenario. **(c)** Behavioural effort gap relative to the highest elasticity benchmark of 6 for the sharing practice. **(d)** First and second derivatives of the modifier with respect to the substitution parameter computed using the central difference method for sharing. Source: CIRCEE-LIFE dynamic coupling.



Supplementary Figure 10. Sensitivity analysis of Rethink and Refuse outcomes. On the x-axis, “Habit 0.45” and “Habit 0.65” denote model runs with habit-persistence parameter values of 0.45 and 0.65. “Elasticity 1.3” and “Elasticity 1.6” denote model runs with values of the substitution elasticity between energy services and other goods and services consumption at 1.3 and 1.6. “Calibrated” denotes model runs with the value of the habit persistence parameter (0.55) and substitution elasticity between energy services and other goods and services consumption (0.98) in the twelve scenarios of the paper.

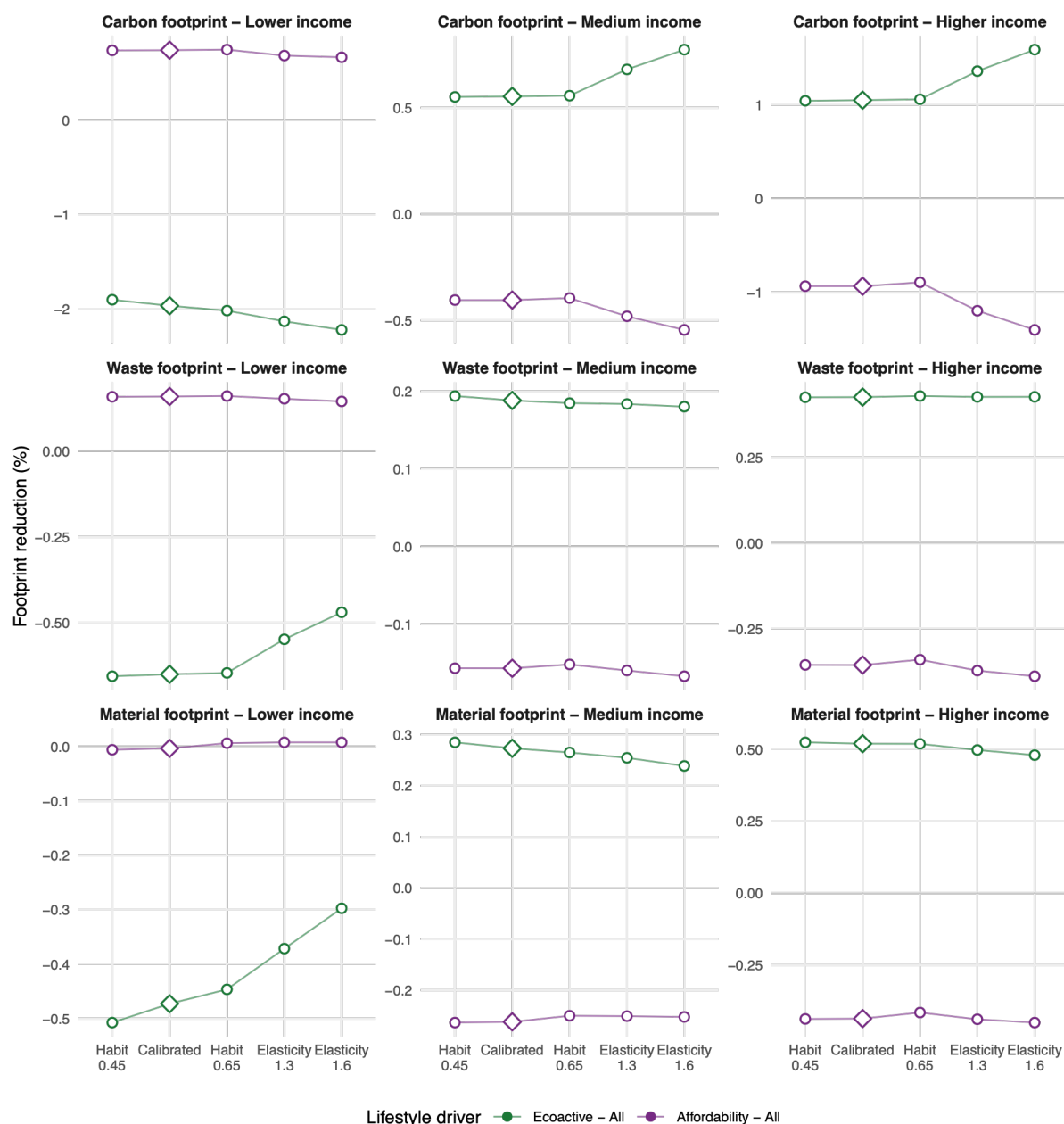


Diamonds: calibrated run (habit persistence 0.55, elasticity of substitution between energy services and other consumption 0.98). Each cell is compared with its own

Supplementary Figure 11. Sensitivity analysis of per-household environmental footprints. The figure shows percentage changes in per-household environmental footprint relative to the Reference. On the x-axis, “Habit 0.45” and “Habit 0.65” denote the model run with values of 0.45 and 0.65 of the habit persistence parameter, and “Elasticity 1.3” and “Elasticity 1.6” are the results of the model for values of 1.3 and 1.6 of the substitution elasticity between energy services and other goods and services consumption. “Calibrated” corresponds to the result of the model with the value of the habit persistence parameter (0.55) and substitution elasticity between energy services and other goods and services consumption (0.98) in the twelve scenarios of the paper.

Sensitivity of environmental footprints

Change relative to the zero-modifier reference; positive values indicate footprint reductions

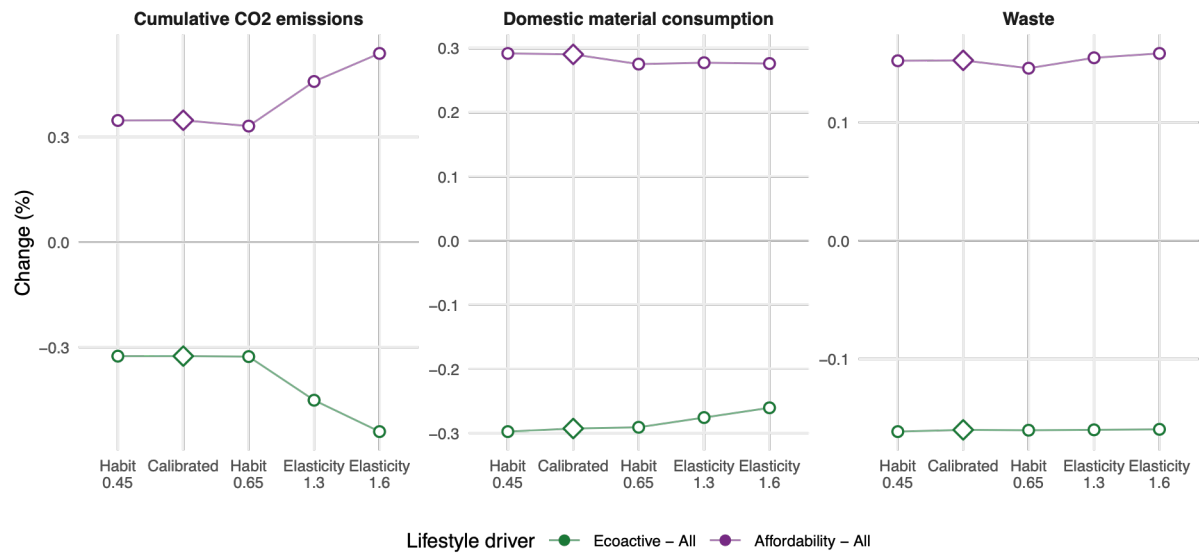


Diamonds: calibrated run (habit persistence 0.55, elasticity of substitution between energy services and other consumption 0.98). Each cell is compared with its own

Supplementary Figure 12. Sensitivity analysis of macro-level environmental outcomes. On the x-axis, “Habit 0.45” and “Habit 0.65” are the results of the model for values of 0.45 and 0.65 of the habit persistence parameter, and “Elasticity 1.3” and “Elasticity 1.6” are the results of the model for values of 1.3 and 1.6 of the substitution elasticity between energy services and other goods and services consumption. “Calibrated” corresponds to the result of the model with the value of the habit persistence parameter (0.55) and substitution elasticity between energy services and other goods and services consumption (0.98) in the twelve scenarios of the paper.

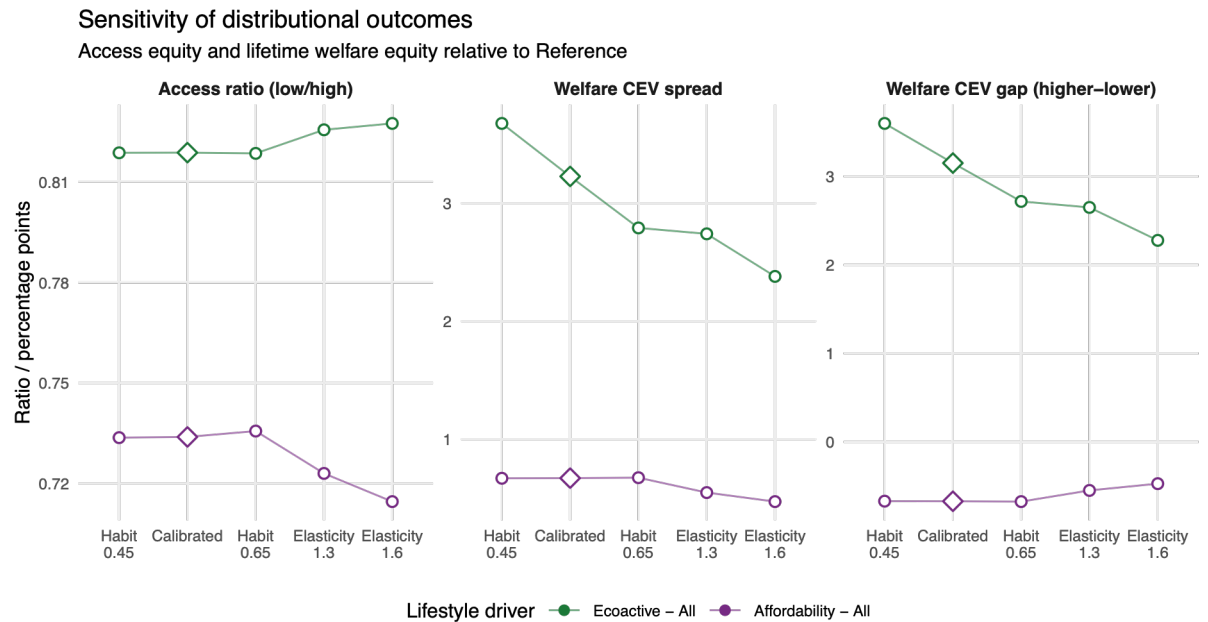
Sensitivity of macro-level environmental outcomes

Change relative to the zero-modifier reference



Diamonds: calibrated run (habit persistence 0.55, elasticity of substitution between energy services and other consumption 0.98). Each cell is compared with its own

Supplementary Figure 13. Sensitivity analysis of distributional outcomes. On the x-axis, “Habit 0.45” and “Habit 0.65” are the results of the model for values of 0.45 and 0.65 of the habit persistence parameter, and “Elasticity 1.3” and “Elasticity 1.6” are the results of the model for values of 1.3 and 1.6 of the substitution elasticity between energy services and other goods and services consumption. “Calibrated” corresponds to the result of the model with the value of the habit persistence parameter (0.55) and substitution elasticity between energy services and other goods and services consumption (0.98) in the twelve scenarios of the paper.



Diamonds: calibrated run (habit persistence 0.55, elasticity of substitution between energy services and other consumption 0.98). Each sensitivity run is compared w