

Appendix The linear relationship between NREU saving and the mass of R-PET in the system

Define *NREU saving* : $E_{ref} - E_{recycl}$

Where:

E_{ref} : cradle-to-grave NREU of the reference system (GJ/FU)

E_{recycl} : cradle-to-grave NREU of a recycling system (GJ/FU)

E_{ref} consists of the NREU of two life stages: the production of V-PET and MSWI with energy recovery.

$$E_{ref} = FU * (NREU_{V-PET} + NREU_{MSWI}) \quad \text{Equation (5)}$$

Where:

FU : functional unit, which is 1000 kg PET polymer (regardless the shares of bottles and fibre)

$NREU_{V-PET}$: cradle-to-factory gate NREU of one tonne of V-PET, which is 66.64 GJ/t in Table 2.

$NREU_{MSWI}$: NREU of incinerating one tonne PET waste in a MSWI plant with energy recovery, recovery rate = 60%.

E_{recycl} is determined by three elements: the amount of V-PET (and the related impact), the amount of R-PET (and the related impact) and the amount of PC waste in the system (and the related impact).

$$E_{recycl} = M_{V-PET} * NREU_{V-PET} + M_{R-PET} * NREU_{R-PET} + M_{MSWI} * NREU_{MSWI} \quad \text{Equation (6)}$$

Where:

M_{V-PET} : quantity of V-PET in the recycling system (tonne)

M_{R-PET} : quantity of R-PET in the recycling system (tonne/FU)

M_{MSWI} : quantity of total amount of post-consumer PET ended up in a MSWI with energy recovery in the recycling system (tonne)

$NREU_{R-PET}$: NREU (GJ) of the recycling process per tonne delivered R-PET (the recycling process includes bottle waste collection, sorting, flake production and pellet production; not including the feedstock energy of PET)

$$\therefore \quad FU = M_{V-PET} + M_{R-PET}, \quad \text{and} \quad M_{MSWI} = FU - (M_{R-PET}/\eta)$$

($\eta = 95\%$, is material efficiency of the recycling process)

Equation (2) can be rewritten into:

$$\begin{aligned} E_{recycl} &= (FU - M_{R-PET}) * NREU_{V-PET} + M_{R-PET} * NREU_{R-PET} + (FU - M_{R-PET}/\eta) * NREU_{MSWI} \\ &= FU * (NREU_{V-PET} + NREU_{MSWI}) \\ &\quad + M_{R-PET} * (NREU_{R-PET} - NREU_{V-PET} - NREU_{MSWI}/\eta) \end{aligned} \quad \text{Equation (7)}$$

NREU saving = Equation (5) - Equation (7)

$$E_{ref} - E_{recycl} = M_{R-PET} * (NREU_{V-PET} - NREU_{R-PET} + NREU_{MSWI}/\eta)$$

$$\therefore \quad (E_{ref} - E_{recycl}) / M_{R-PET} = NREU_{V-PET} - NREU_{R-PET} + NREU_{MSWI}/\eta = \mathbf{43.5 \text{ GJ/t}} \quad \text{Equation (8)}$$

($NREU_{V-PET} = 9.5 \text{ GJ/t}$, $NREU_{R-PET} = 66.6 \text{ GJ/t}$, $NREU_{MSWI} = -13 \text{ GJ/t}$, $\eta = 95\%$)

Relace NREU with global warming in Equation (8), the GHG-emission saving per tonne R-PET can be calculated at 2.4 t CO₂ eq./t.