MATH MODEL FOR REMANUFACTURING
See Gutowski et al Remanufacturing and Energy Savings ES&T 2011

$E^N_{Tot} = E^N_M + E^N_T + E^N_U + E^N_D$

$E^R_{Tot} = E^R_M + E^R_T + E^R_U + E^R_D$

$E^N - E^R = (E^N_M - E^R_M) + (E^N_T - E^R_T) + (E^N_U - E^R_U) + (E^N_D - E^R_D)$

The terms E^i_j are defined below.

E, refers to energy requirement

i = N, refers to new version
i = R, refers to remanufactured version

j = Tot, total or cumulative sum across the lifecycle
j = M, refers to new materials processing and manufacturing (when i = N) or remanufacturing (when i = R)
j = T, refers to transportation
j = U, refers to use
j = D, refers to disposal or end-of-life (EOL)

L = length of service life of product (in units of time)
e_U = energy consumed for providing service for a unit time, related to energy efficiency of the product.

Note that:

- in almost all cases $E^N_M > E^R_M$
- generally $E^N_T > E^R_T$ but in many cases this component is small (see text)
- $E^N_U - E^R_U$ can be written as $(e^N_U * L_N - e^R_U * L_R)$ → this term plays a large role (see text). In many cases, remanufacturing brings product back to like-new making $L_N \cong L_R$. However, if this is not true it can be easily included into the model.
- if EOL treatment is the same then $E^N_D - E^R_D \cong 0$.