

Table S1: Set of dissipation reactions used to identify thermodynamically infeasible EGCs. Each dissipation reaction were iteratively added to the model, selected as the objective function, and subsequently maximized when all exchange reactions were constrained to zero. Any non-zero optimal objective value indicated the presence of an EGC.

Energy carrier	Dissipation reaction
ATP	$\text{ATP} + \text{H}_2\text{O} \longrightarrow \text{ADP} + \text{Phosphate} + \text{H}^+$
CTP	$\text{CTP} + \text{H}_2\text{O} \longrightarrow \text{CDP} + \text{Phosphate} + \text{H}^+$
GTP	$\text{GTP} + \text{H}_2\text{O} \longrightarrow \text{GDP} + \text{Phosphate} + \text{H}^+$
UTP	$\text{UTP} + \text{H}_2\text{O} \longrightarrow \text{UDP} + \text{Phosphate} + \text{H}^+$
ITP	$\text{ITP} + \text{H}_2\text{O} \longrightarrow \text{IDP} + \text{Phosphate} + \text{H}^+$
NADH	$\text{NADH} \longrightarrow \text{NAD}^+ + \text{H}^+$
NADPH	$\text{NADPH} \longrightarrow \text{NADP}^+ + \text{H}^+$
FADH_2	$\text{FADH}_2 \longrightarrow \text{FAD} + 2 \text{H}^+$
Ubiquinol-9	$\text{Ubiquinol-9} \longrightarrow \text{Ubiquinone-9} + 2 \text{H}^+$
Acetyl-CoA	$\text{Acetyl-CoA} + \text{H}_2\text{O} \longrightarrow \text{acetate} + \text{CoA} + \text{H}^+$
L-glutamate	$\text{L-glutamate} + \text{H}_2\text{O} \longrightarrow \text{2-oxoglutarate} + \text{Ammonium} + 2 \text{H}^+$