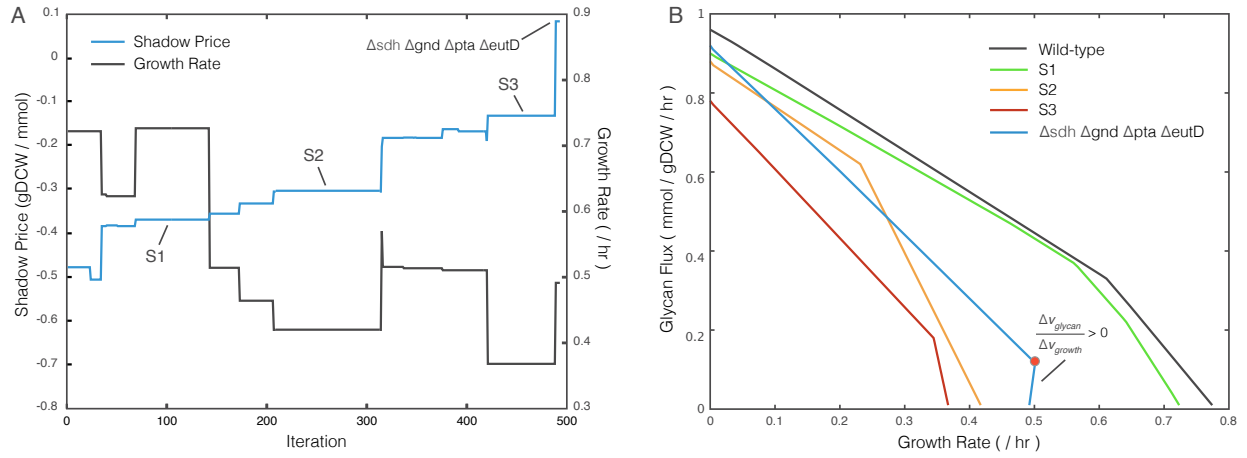**Supplementary Materials**

Fig. 1: Representative simulated annealing simulation results identifying a growth-coupled strain of type EcM1. **(A)** Shadow price and FBA-maximized growth rate versus iteration identifying strain $\Delta sdh\Delta gnd\Delta pta\Delta eutD$. **(B)** Production envelopes of the strains at iteration points indicated in A. The simulation is terminated once a positive shadow price is found, visualized by the slope of the production envelope. The red dot indicates the optimal operating point of maximal growth rate for the growth-coupled strain.