Thermodynamics of quantum measurements

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Quantum measurement of a system can change its mean energy, as well as entropy, thus disturbing thermal equilibrium and allowing for work to be extracted. A selective measurement (classical or quantum) can be used as a "Maxwell's demon" to power a single-temperature heat engine (e.g., a Szilard engine), by decreasing the entropy. Quantum mechanically, so can a non-selective measurement, despite increasing the entropy of a thermal state. The maximal amount of work extractable following the measurement is given by the change in free energy: $W=\Delta E-T_{Bath}\Delta S$, where ΔE and ΔS are the changes in the mean energy and the entropy, respectively, due to the measurement. I show that the extractable work in the case of a selective measurement exceeds that of the non-selective measurement by exactly the amount of work needed to reset the memory of the measuring device ("demon"), and furthermore no such resetting is needed in the non-selective case! Consequently, a single-bath engine powered by either kind of measurement works at the same net loss of $T_{Bath}\Delta S_{nonsel.}$ per cycle. By replacing the measurement by a reversible "premeasurement" and allowing a work source to couple to the system and memory, the cycle can be made completely reversible.

[1] N. Erez, G. Gordon, M. Nest, and G. Kurizki, Thermodynamic control by frequent quantum measurements, Nature 452, 724 (2008)

[2] N. Erez, Thermodynamics of quantum measurements, arXiv: 1011.1020