Consider the energy required to process a unit of material (say aluminum) for two processes: 1) milling, and 2) sand casting. We are looking for mathematical expressions, not actual numbers.

1a) Please write down from physical principles the approximate spindle work required to remove 1 cm³ of material by milling.

1b) Now estimate the power required including not only spindle power but also terms that capture the spindle/cutting efficiency and other realistic power requirement for a machine tool.

1c) How would you expect the (Energy/cm³ removed) to vary if you machined the same part but in different sized machines i.e. a small machine and a large machine? State all assumptions.

2a) Please write down from physical principles the approximate energy required to melt 1kg of material.

2b) Now estimate the power required including not only the melting process but also other realistic terms for a casting process.

2c) How would you expect the Energy/kg processed to vary if you made the same part but in different sized foundries, i.e. a large foundry capable of processing many parts, and a small foundry that makes only a few? State all assumptions.

3. How would you expect the overall energy efficiency to compare between a cutting process and a melting process? State all assumptions.