# Miniaturised 'heat engines' could power nanoscale machines of the future

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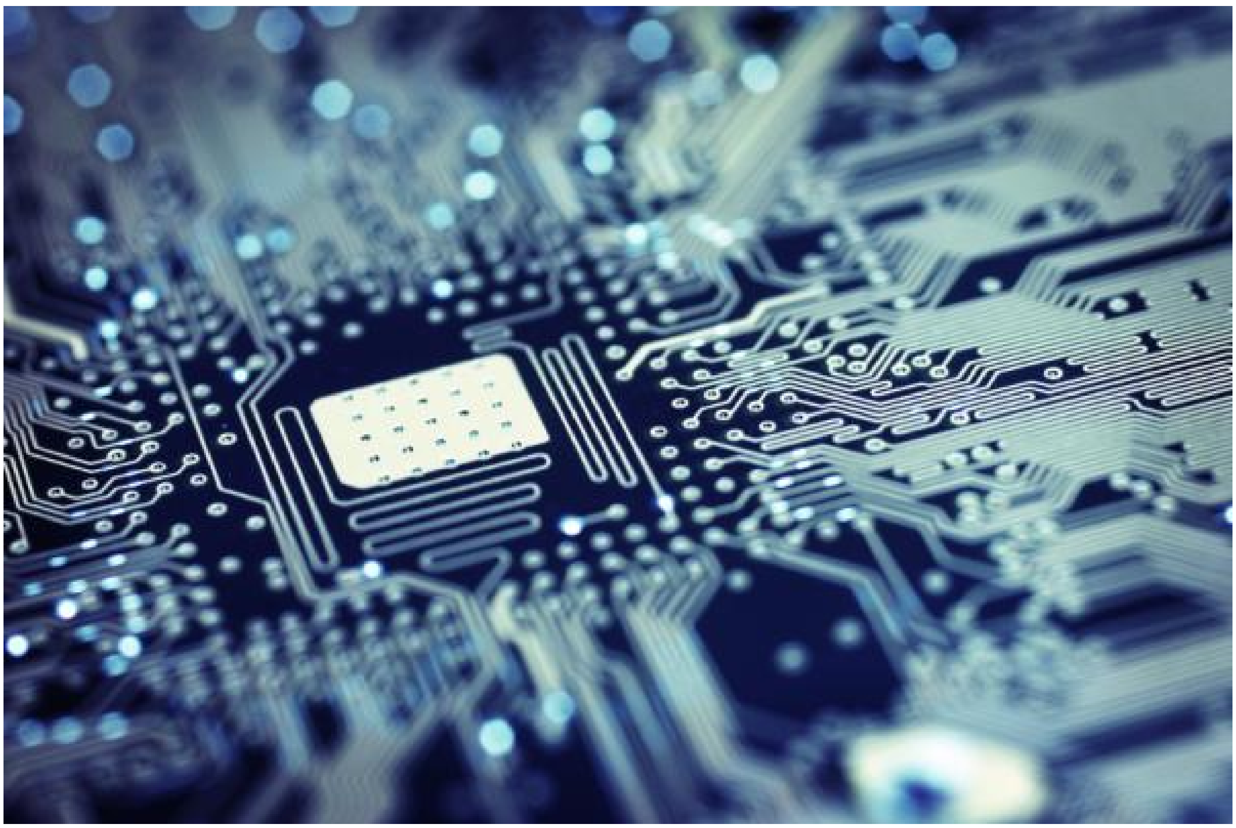

Credit: University of Manchester

Research from The University of Manchester has thrown new light on the use of miniaturised 'heat engines' that could one day help power nanoscale machines like quantum computers.

Heat engines are devices that turn thermal energy into a useful form known as 'work' which can provide power – like any other engine.

Dr Ahsan Nazir, a Senior Lecturer and EPSRC Fellow based at Manchester's Photon Science Institute and School of Physics and Astronomy, wanted to see how heat engines performed at the quantum level, a sub-atomic environment where the classical laws of physics don't always apply.

Heat engines at this scale could help power the miniaturised nanoscale machines of the future, such as components of quantum computers.

Dr Nazir's research, published in the journal *Physical Review E*, showed that heat engines were inclined to lose performance at the quantum scale due to the way such devices exchange energy with external heat reservoirs – and more investigation would be needed to remedy this challenge.

"Heat engines are devices that turn thermal energy into a useful form known as 'work'," explained Dr Nazir.

"Besides being of immense practical importance, the theoretical understanding of factors that determine their energy conversion efficiency has enabled a deep understanding of the classical laws of thermodynamics.

"Recently, much interest has focused on quantum realisations of engines in order to determine whether thermodynamic laws apply also to quantum systems.

"In most cases, these engines are simplified using the assumption that the interaction between the working system and the thermal reservoirs is vanishingly small. At the classical macroscopic scale this assumption is typically valid – but we recognised this may not be the case as the system size decreases to the quantum scale.

"Consensus on how to approach thermodynamics in this so-called strong coupling regime has not yet been reached. So we proposed a formalism suited to the study of a quantum heat engine in the regime of non-vanishing interaction strength and apply it to the case of a four stroke Otto cycle.

"This approach permitted us to conduct a complete thermodynamic analysis of the energy exchanges around the cycle for all coupling strengths. We find that the engine's performance diminishes as the interaction strength becomes more appreciable, and thus non-vanishing system-reservoir interaction strengths constitute an important consideration in the operation of quantum mechanical heat engines."

**More information:** David Newman et al. Performance of a quantum heat engine at strong reservoir coupling, *Physical Review E* (2017). DOI: 10.1103/PhysRevE.95.032139

Provided by University of Manchester