Turbo-expander for novel building energy systems

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Turbo-expanders have a broad range of applications and provide a way to capture the energy lost in industrial processes (e.g., natural gas facilities and refineries). They are mostly used for energy recovery and power generation. Virtually any high-temperature or high-pressure gas is a potential resource for energy recovery. Thus, by replacing a conventional control valve or regulator with a turbo-expander, the energy contained in a working fluid, that would otherwise be lost, can be converted to electricity or be converted to useful shaft work. The higher the flow rate and pressure differential, the potential energy output is higher.

In this project, it is desired to study the performance of a turbo-expander linked to a centrifugal compressor (common shaft)- basically a turbocharger (https://en.wikipedia.org/wiki/Turbocharger, see image below) but here we will be optimizing for a different purpose- building energy systems using unconventional non-toxic working fluids.

Low pressure gas will be compressed through the compressor, while high pressure gas will be expanded through the turbo-expander. The idea is to quantify the net amount of work required to run the system based on various working fluids (gases) and thermodynamic properties (various Temperatures and Pressures). The study will focus primarily on using CO_2 at high pressure and temperature as the working fluid. However, other fluids may be considered as well. The study has two-phases: 1) theoretical and analytical study of the system for various pressure ratio and working fluids; 2) use an instrumented protype of the system to study experimentally a limited range of pressure ratios using CO_2 or air as the working fluid. The analytical model built in phase 1 will be validated with experimental data obtained in phase 2, and if time allowed, the model will be used for optimization of the system for minimizing electrical power input to the compressor.