Efficient Methods to Pressurize Liquid and Gaseous CO2 Using 1 Kilowatt of Energy

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A technical assessment comparing four ways to apply 1 kilowatt of energy to pressurize carbon dioxide. Evaluates liquid pumping, mechanical compression, resistance heating, and cavitation discs, and identifies the most efficient method for both liquid and gaseous CO2.

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Introduction

As industries increasingly rely on carbon dioxide (CO2) for energy systems, cooling cycles, and supercritical processes, understanding how to efficiently pressurize CO2 becomes critical. Whether the CO2 is in liquid or gaseous form, the method of applying energy directly affects pressure, temperature, and system efficiency.

This article evaluates four ways to use one kilowatt of electrical power to increase CO2 pressure and temperature:

1. Pumping liquid CO2
2. Using resistance heat
3. Operating a refrigeration compressor
4. Using a cavitation disc

1. Pumping Liquid CO2

When CO2 is in liquid form, a liquid pump is the most efficient means of pressurization. Liquids are nearly incompressible, meaning the mechanical work needed to raise their pressure is minimal.

For example, with one kilowatt of electrical input and a pump efficiency of 70 percent, a liquid CO2 flow of 0.01 kilograms per second can achieve a pressure increase of roughly 63 megapascals (about 9,000 psi). The temperature rise is minimal, typically just a few degrees.

Conclusion: Pumping liquid CO2 provides extremely high pressure with minimal temperature gain, making it the most efficient option for pressurization.

2. Heating CO2 by Resistance

Resistance heating directly converts electrical energy into heat. While this increases the temperature of CO2, it does not effectively increase pressure unless the CO2 is in a sealed volume.

In open or flow systems, resistive heating produces thermal expansion but negligible pressure increase. Thus, it is inefficient for pressurization but useful when the goal is to raise temperature.

Conclusion: Resistance heating increases temperature, not pressure.

3. Compressing Gaseous CO2 with a Mechanical Compressor

For gaseous CO2, a mechanical compressor is the correct tool. One kilowatt of power applied to a gas compressor with 70 percent efficiency can compress CO2 from 1 bar to about 3 bar at a mass flow of 0.01 kilograms per second. The discharge temperature rises to roughly 140 degrees Celsius.