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Distributed ammonia synthesis

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Since the early 1900s, the supply of natural fertilizers has not permitted food production adequate for the growing population. Synthetic ammonia, developed by 1915, provided synthetic nitrogen fertilizer which allowed significant increases in food production around the world. This fertilizer is made with energy from fossil fuels, especially natural gas. In addition, in the middle of the 20th century, research on improved wheat varieties resulted in a "Green Revolution," requiring still more nitrogen fertilizer, with an associated increase in fossil fuel use and carbon emissions.

This work begins to develop a small-scale ammonia synthesis plant powered by wind energy. The energy used is stranded, far from urban population centers but near locations of fertilizer demand. The wind energy drives pressure swing absorption of air to make nitrogen, and electrolysis of water to make hydrogen. These are combined in the small-scale continuous Haber process to synthesize ammonia. An analysis of this small plant shows a rate controlled by three resistances which are not always in series: those of catalytic reaction, of the ammonia separation by condensation, and of the unreacted gas recycle. Higher temperatures and separation by absorption can raise the conversion per pass from 25% to 95% while decreasing operating pressure by ten times. While our focus is ammonia as fertilizer, the ammonia can also be used as fuel. Together, these studies explore the feasibility of a different chemical industry based on scaling down processes to harvest local energy.

Keywords: ammonia, wind power, small scale