Relationships among the energy, emergy, and money flows of the United States from 1900 to 2011

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Energy Systems Language models of the resource base for the U.S. economy and of economic exchange were used, respectively, (1) to show how energy consumption and emergy use contribute to real and nominal gross domestic product (GDP) and (2) to propose a model of coupled flows that explains high correlations of these inputs with measures of market-based economic activity. We used a weight of evidence approach to identify relationships among emergy, energy, and money flows in the U.S. from 1900 to 2011. All measures of quality adjusted energy consumption had a relationship with nominal GDP that was best described by a hyperbolic function plus a constant and the relationship between all measures of energy consumption and real GDP was best described by a second order polynomial. The fact that energy consumption per unit of real GDP declined after 1996 as real GDP continued to increase indicates that energy conservation or a shift toward less energy intensive industries has resulted in lower fossil fuel use and reduced CO_2 emissions while maintaining growth in real GDP. Since all energy consumption measures versus real GDP deviated from a power law relationship after 1996; while total emergy use did not, we concluded that total emergy use captured more of the factors responsible for the increase in real GDP than did energy measures alone. As a result, total emergy use may be a better measure to quantify the biophysical basis for social and economic activity in the information age.