Energy Return on Energy Invested (EROEI)

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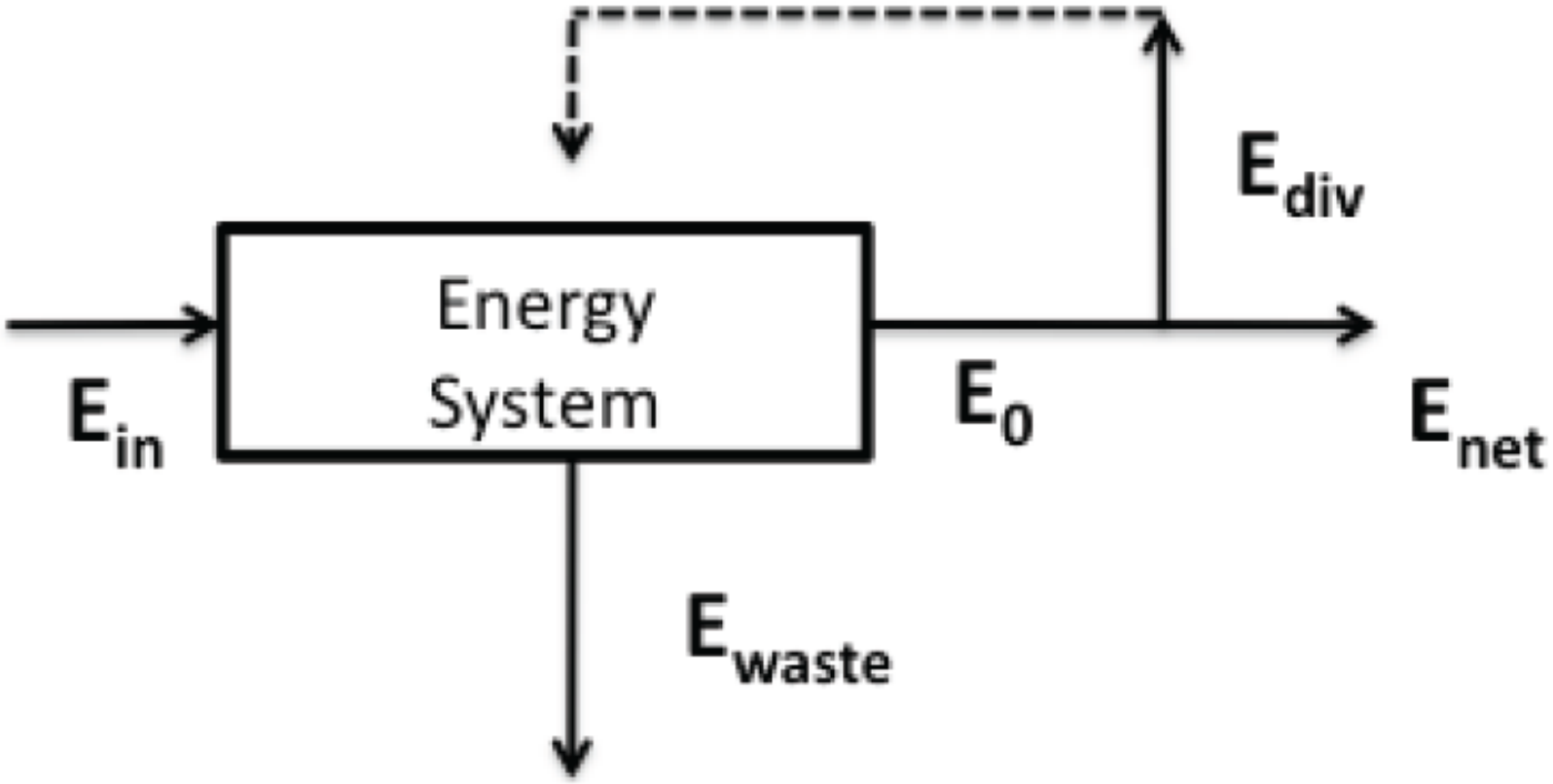
MAE 119

Schematic of Energy Flow

Figure1. Schematic of an energy system.



Deng & Tynan, *Sustainability* 2011, 2433

Net Useful Energy & EROEI

With these considerations in mind, the net useful energy available for needs other than the energy system itself, E_{net}, can be expressed in terms of the energy system output energy, E_o, and the diverted energy, E_{div} as

$$E_{net} = E_0 - E_{div} \tag{1}$$

We now define the energy returned on energy invested (EROEI), E_R, as the ratio

$$E_R = \frac{E_0}{E_{div}} \tag{2}$$

1st Law of Thermo & EROEI Gives

$$E_{in} > E_{net}\left(\frac{E_R}{E_R - 1}\right)$$

Deng & Tynan, *Sustainability* 2011, 2433

Estimated EROEI of Some Primary Energy Sources

Table 1. EROEI for energy sources and fuels. Values taken from reference [19].

Fuel	Coal	Oil	Gas	Ethanol	Biodiesel	Nuclear	Solar PV	Hydropower	Wind
EROEI	50–80	20–40	15–25	1–1.5	1.5–3	5–15	8–10	20–40	15–25

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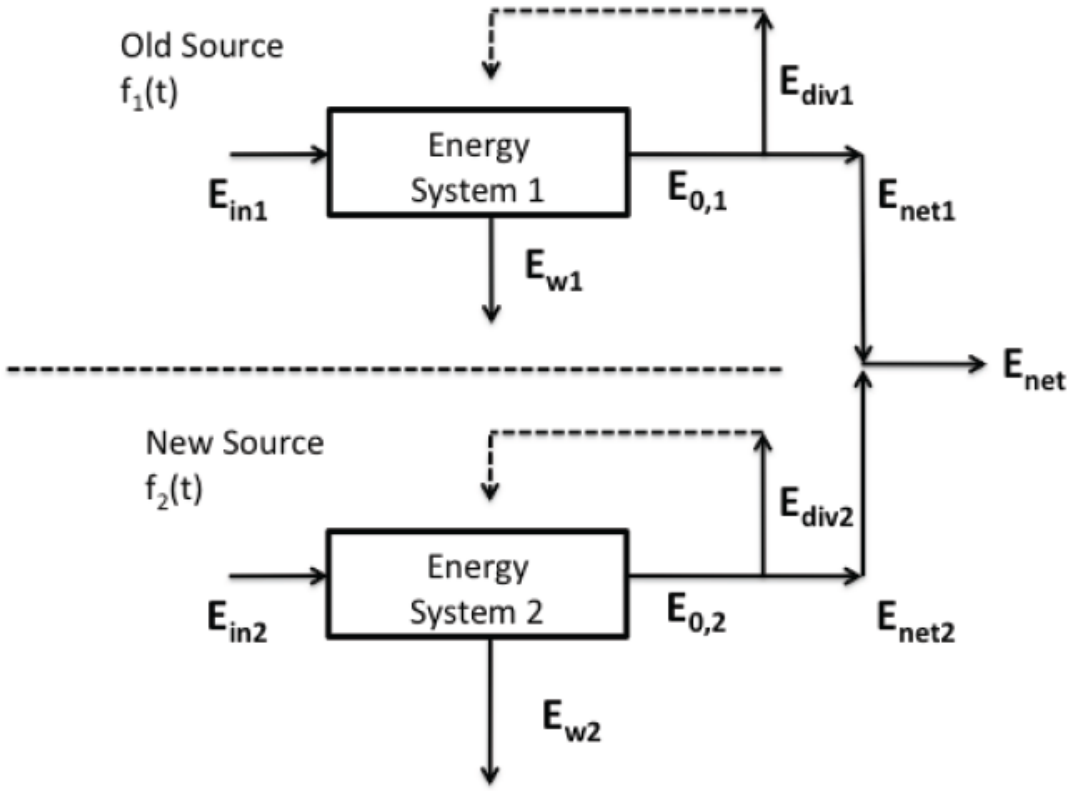
Transitioning to a new energy system

Figure 3. Systems 1 and 2 represent the old and new energy system, respectively.



Transitioning to a new energy system

Assume new technology follows substitution model:

$$f(t) = \frac{1}{1 + e^{-r_0(t-t_o)}}$$

The old and new energy sources capture all of the market:

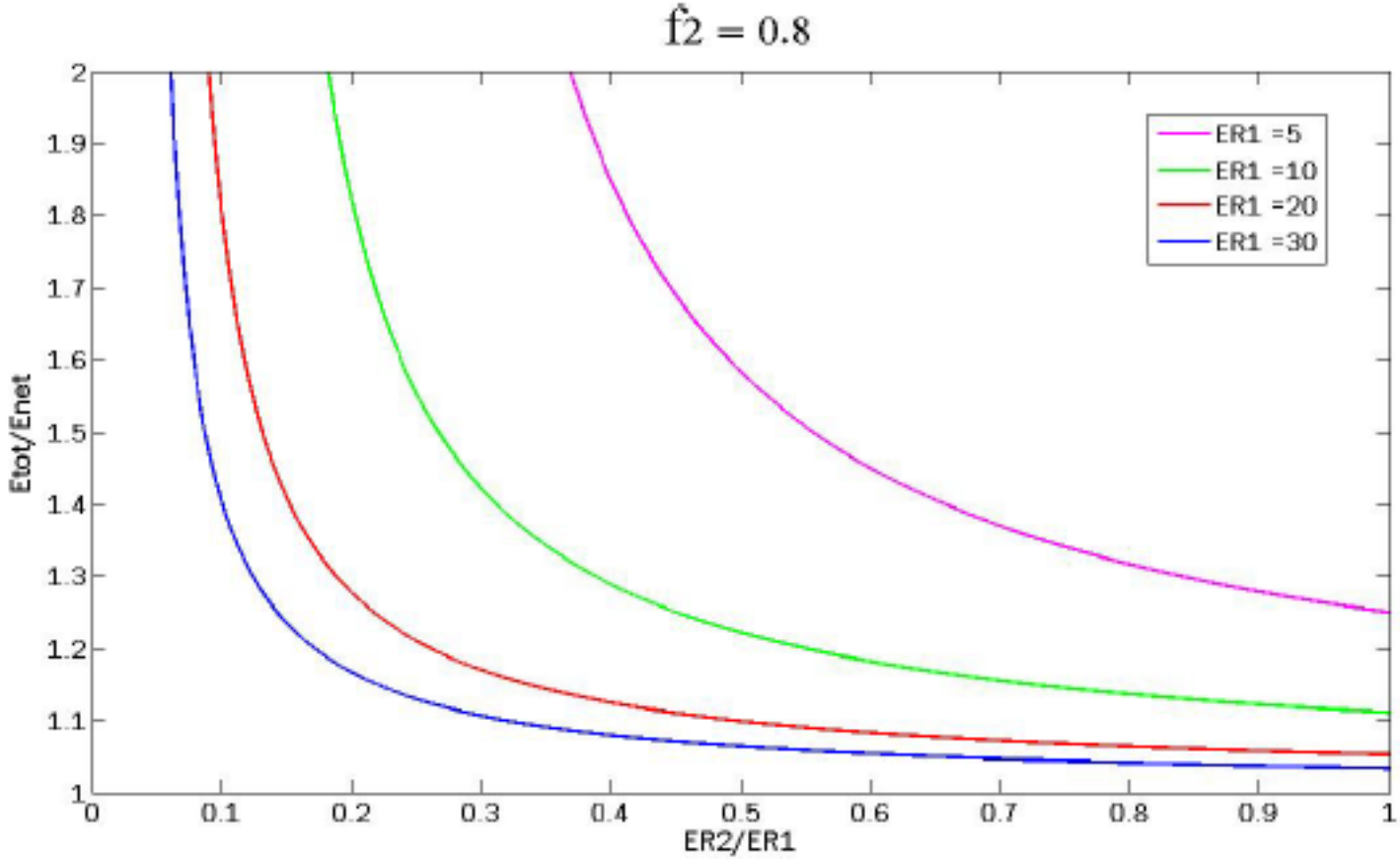
$$f_1 = 1 - f_2.$$

We can then find ratio of TOTAL DEMAND to NET AVAILABLE ENERGY

$$\frac{E_{tot}}{E_{net}} \geq (1 - f_2)\left(\frac{E_{R1}}{E_{R1} - 1}\right) + f_2\left(\frac{E_{R2}}{E_{R2} - 1}\right)$$

EROEI of new system impacts total energy demand

Figure 4. Plot of E_{tot}/E_{net} *vs.* ratio of EROEI, E_{R2}/E_{R1} for several values of E_{R1}.



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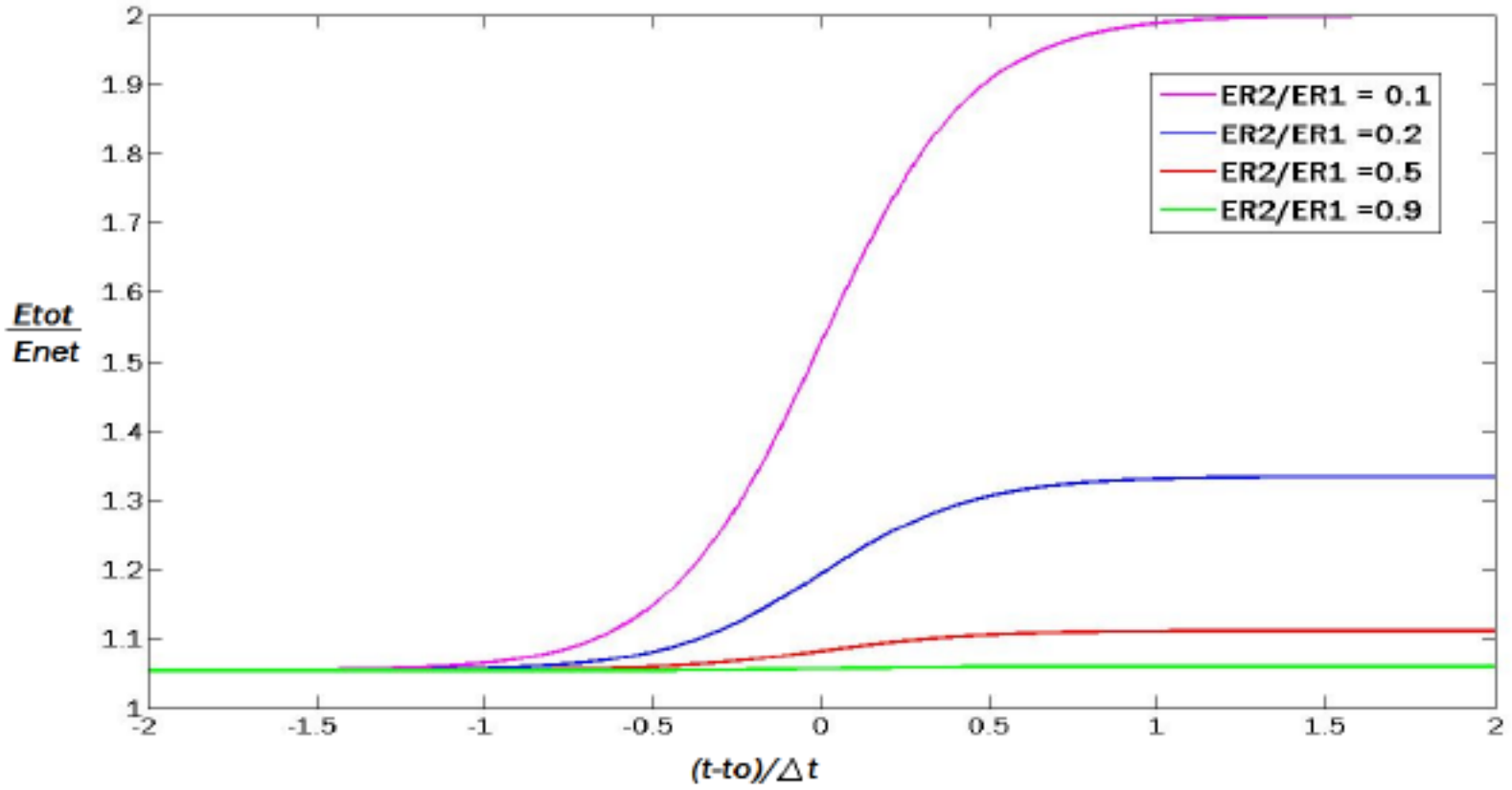
Transition to lower EROEI sources increases total energy demand

Figure 5. Time Evolution for different E_{R2}/E_{R1} ratios.



Conclusions

- EROEI is an important concept!
- We've enjoyed high EROEI (>>10) for last 100 years
- Replacement sources tend to have lower EROEI (~10 or so, sometimes lower)
- Impacts the cost, total demand for energy
- Crucial to identify sources with EROEI >2-3!