Dispelling the misconception of low-EROI photovoltaics

(*Peak Oil is here, let us not squander what is left*)

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The importance of EROI

- **Energy Return on Energy Investment (EROI)** has been touted as the ultimate indicator of the viability of an energy option

- The existing **EROI** literature has repeatedly downplayed PV as being hampered by intrinsically low **EROI**

- We will show that this is largely a *misconception* based on *outdated energy performance data* and, more importantly, *inconsistent calculations*

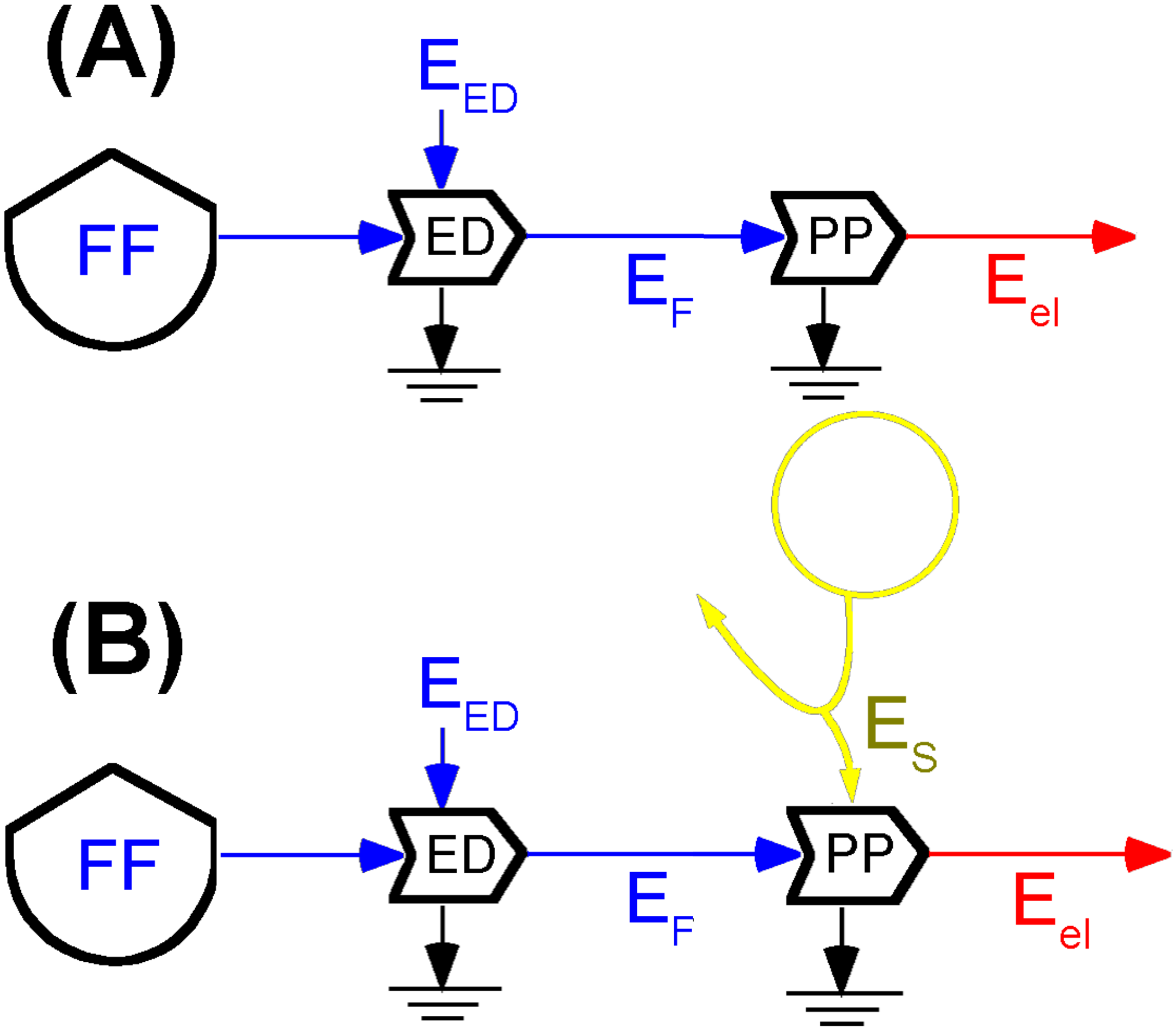
EROI definitions

$$\mathrm{EROI}_F = \frac{\text{Quantity of energy supplied [MJ]}}{\text{Quantity of energy used in supply process [MJ]}}$$

$$\mathrm{EROI}_{el} = \frac{\text{Cumulative electricity generated [MJ]}}{\text{Cumulative primary energy required [MJ]}}$$

Source: **Earth. Cleveland C.J. (Ed.), Encyclopedia of Earth**
http://www.eoearth.org

Thermal vs. PV electricity generation



Thermal electricity EROI calculations

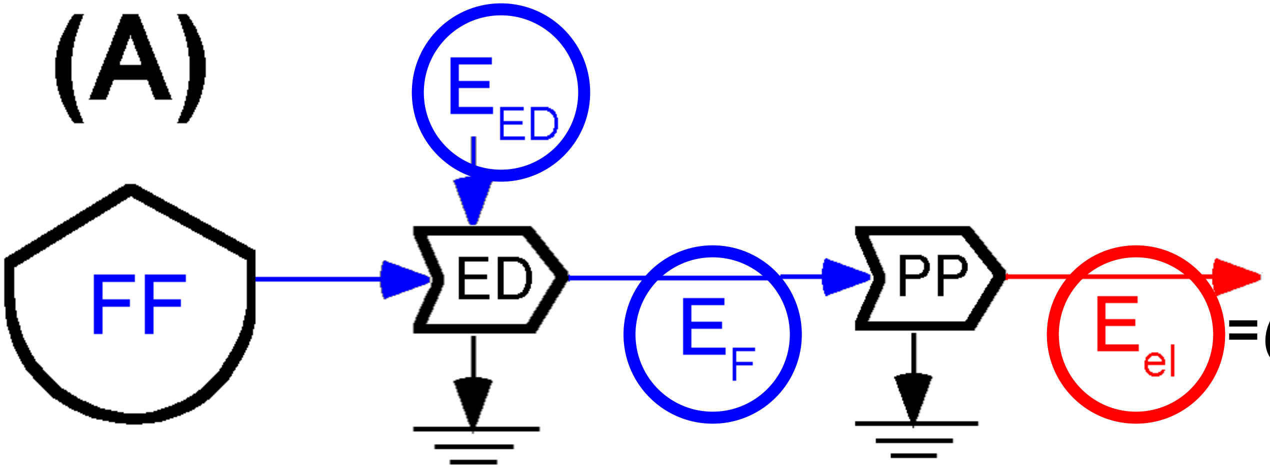
$$EROI_F = E_F/E_{ED} = 40$$

$$EROI_{el} = E_{el}/E_{ED}$$

$$= EROI_F * E_{el}/E_F$$

$$= 40*0.35 = 14$$

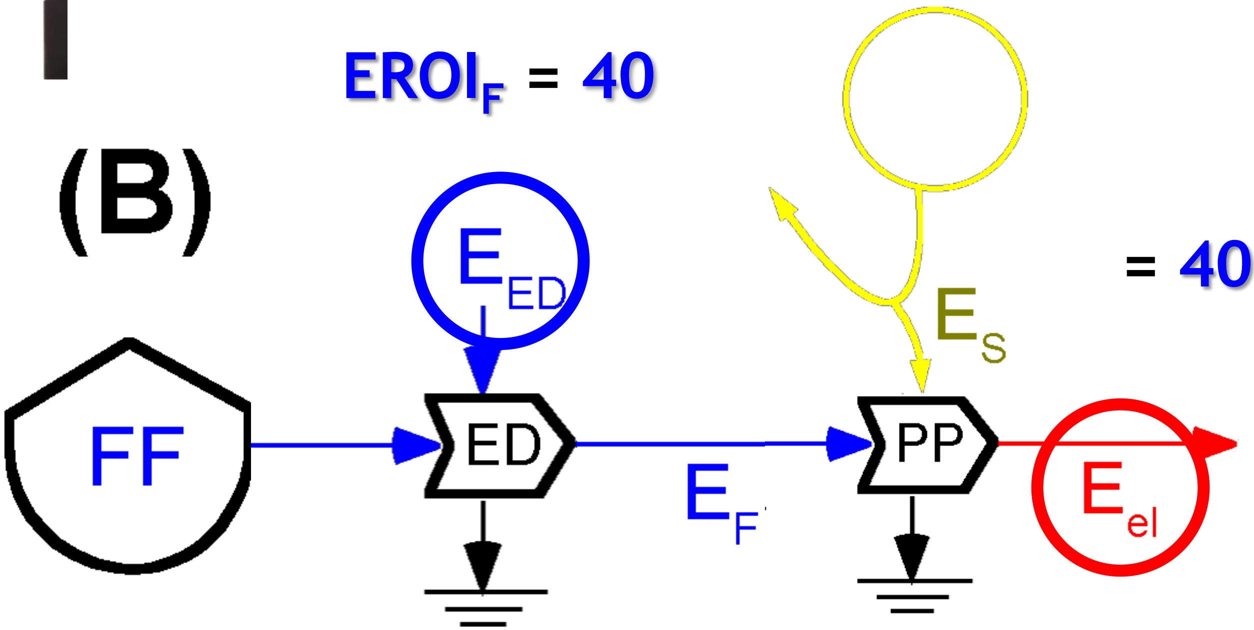
(A)



$$=(E_F*0.35)$$

PV electricity EROI calculations

$EROI_F = 40$



$EROI_{el} = E_{el}/E_{ED}$

$= EROI_F * E_{el}/E_F$

$= 40*16,000/1,340$

≈ 480

$CED = E_F + E_{ED} = E_F + E_F/40$

$\rightarrow E_F = 40/41 * CED = 1,340\ MJ/m^2$

12,500 MJ/kWp
= 1,375 MJ/m^2

$E_{el} = E_S * \eta * PR * T = 16,000\ MJ/m^2$

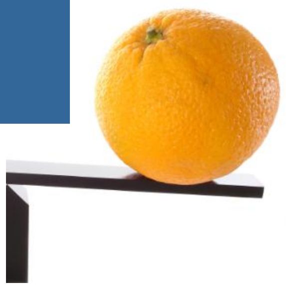
1,700 kWh/(m^2*yr)

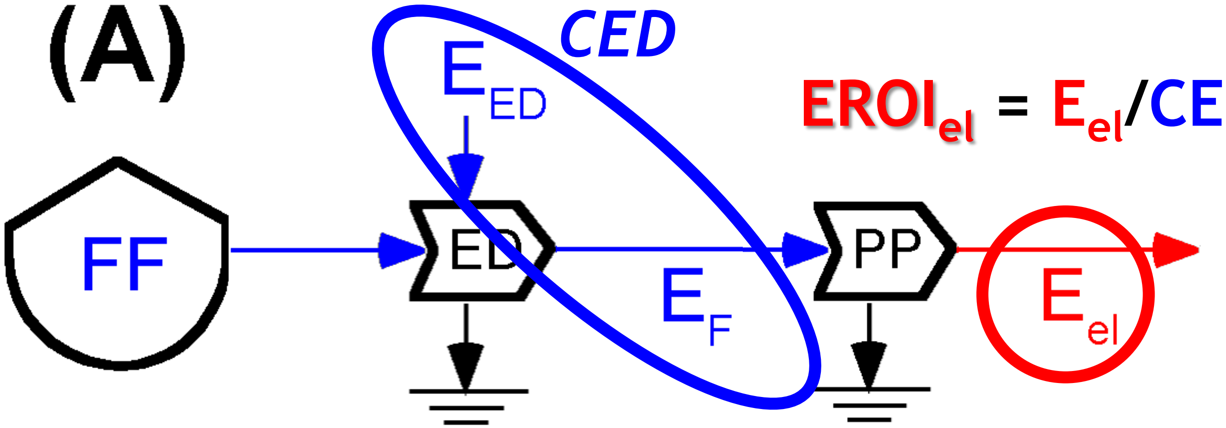
11%

80%

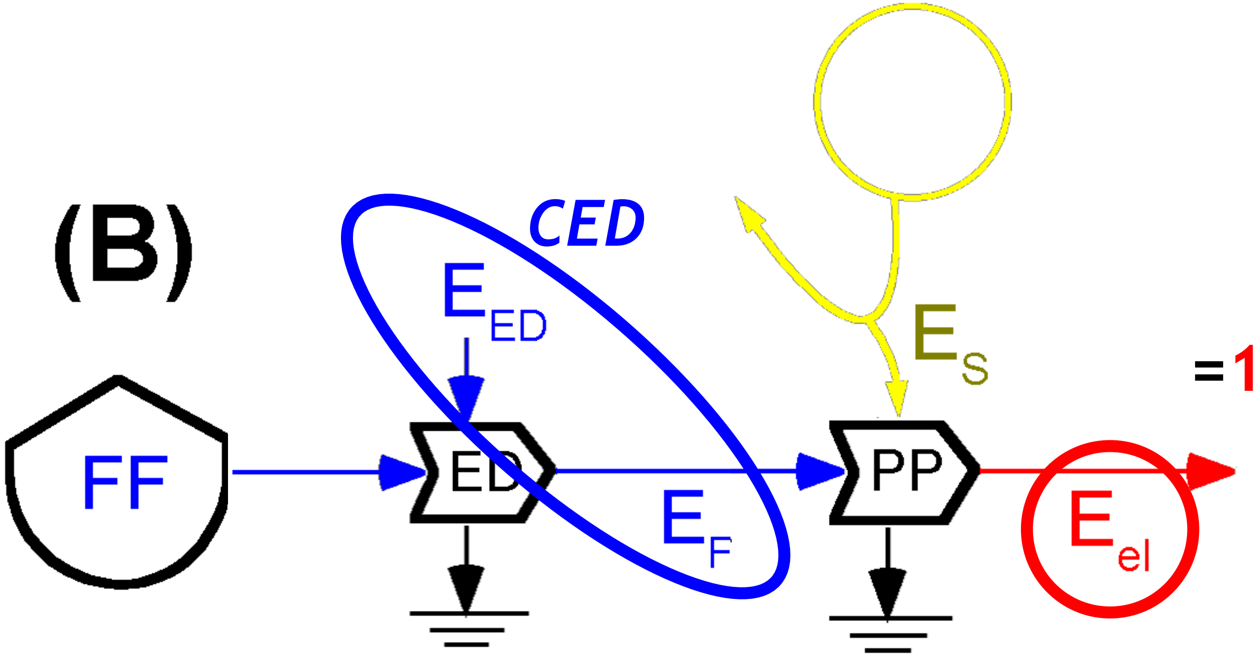
30 yr

Alternative system boundaries





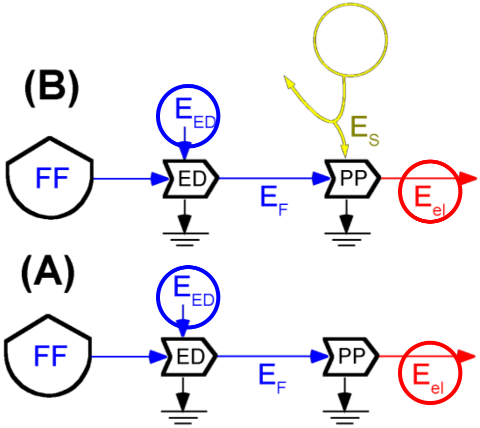
$EROI_{el} = E_{el}/CED \approx 0.34$



$EROI_{el} = E_{el}/CED$

$= 16{,}000/1{,}375 \approx 12$

Consistency is paramount!



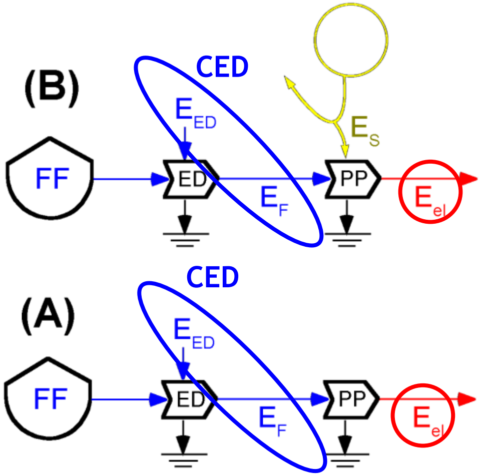
480

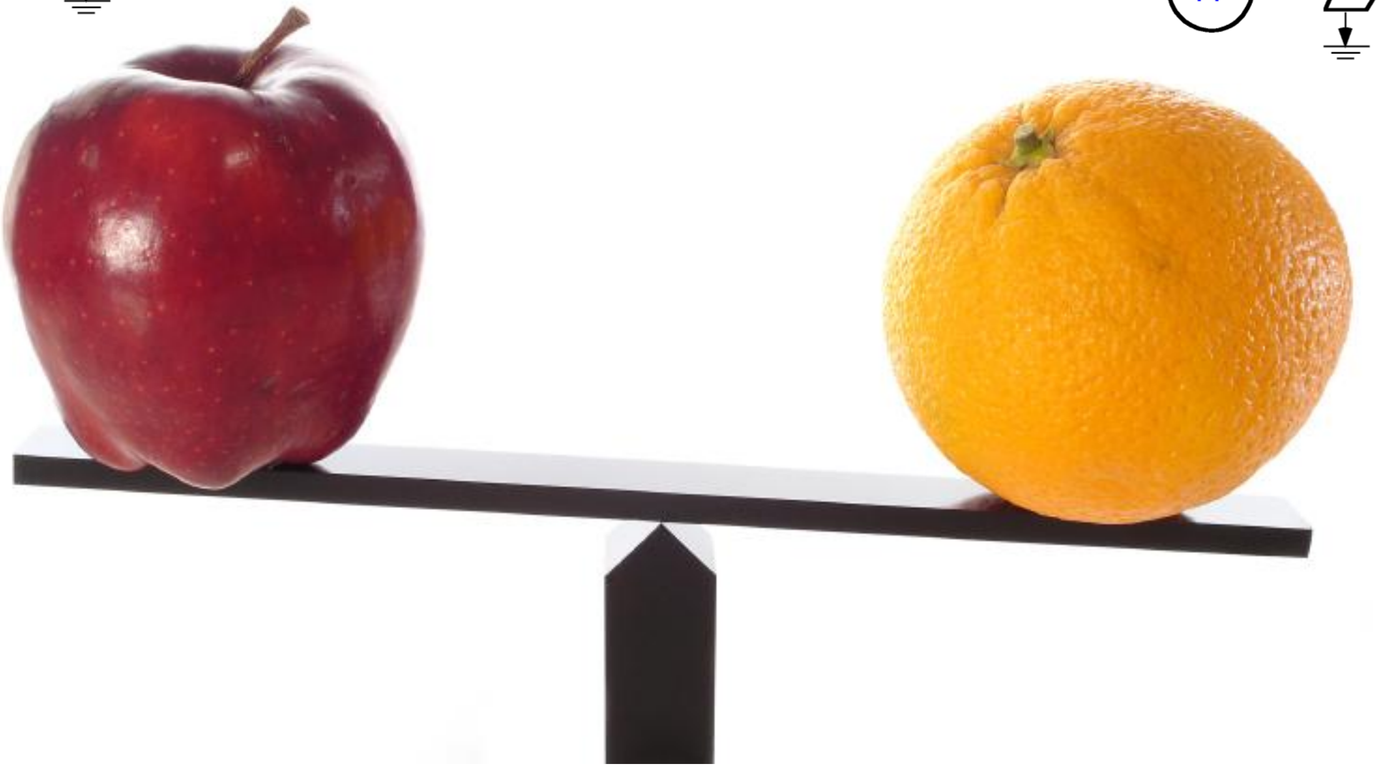
12

$$\frac{\text{EROI}_{el}\text{ (PV)}}{\text{EROI}_{el}\text{ (thermal)}} \approx 34$$

14

0.34





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What about EROI = T/EPBT ?

$$\text{EPBT [yr]} = \frac{\text{CUMULATIVE PRIMARY ENERGY DEMAND [MJ]}}{\text{ANNUAL PRIMARY ENERGY “OUTPUT”} \atop \text{(= “SPARED” PRIMARY ENERGY, back-calc. assuming grid mix) [MJ/year]}}$$

$$\text{EPBT} = \text{CED} / \text{SE} \approx 0.8 \text{ yr}$$

$CED = E_F + E_{ED}$

$= 1{,}375 \text{ MJ/m}^2$

$SE = E_{el}/(\eta_{grid} * T)$ (“spared” primary energy in 1 year)

$= 16{,}000/(0.31*30)$

$\approx 1{,}700 \text{ MJ/(m}^2\text{*yr)}$

What about EROI = T/EPBT ?

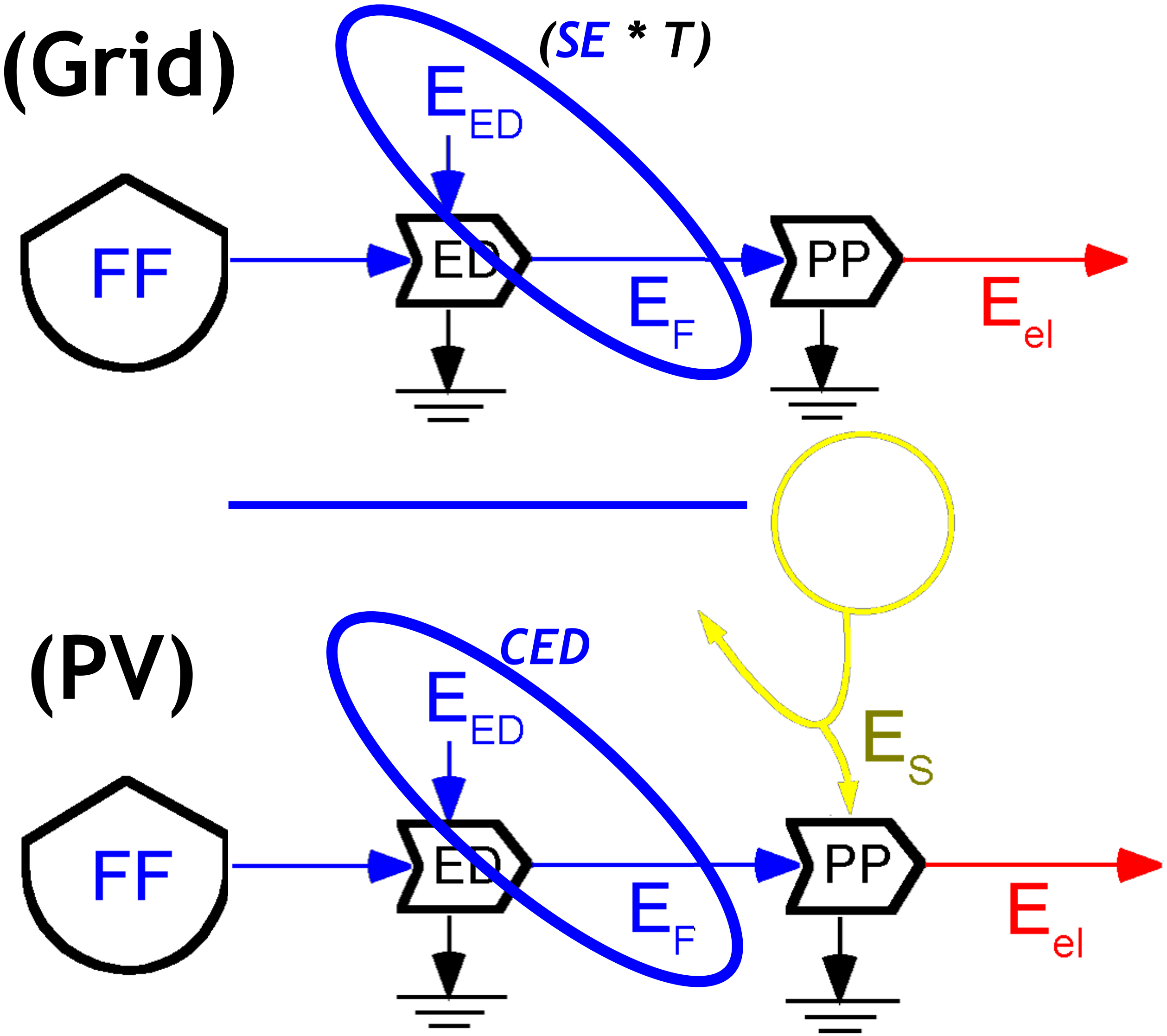
EROI = T / EPBT

= (**SE** * T) / **CED**

↑

(spared primary energy over entire lifetime)

More inconsistency!



What about EROI = T/EPBT ?

$$EROI = T / EPBT \approx 30/0.8 = 37.5$$

$$= (SE * T) / CED$$

(spared primary energy over entire lifetime)

No longer comparable to $EROI_{el}$ of thermal electricity!

*Applying this definition of **EROI** to the current grid mix would lead to $EROI_{grid} = 1$ by definition*

➔ *$EROI_{PV} = 37.5$ in this case means that PV makes 37.5 times more efficient use of FF fuels than the current grid*

Conclusions

- A hitherto pending *fundamental inconsistency* in the calculation of the **EROI** of PV vs. thermal electricity has been exposed and solved

- **EROI = T / EPBT** is a ratio of *primary energies*, and *should NOT be compared* to **EROI_{el}** for thermal electricity

- Adopting consistent boundaries and up-to-date life cycle performance data shows the **EROI** of modern PV to be <u>one order of magnitude higher</u> than that of typical thermal electricity

A look ahead

- Current PV technologies are *improving fast*, and *new technologies* may soon become feasible…
- *BUT:* PV is not a base-load technology, and deploying it on a large scale will require extensive *energy storage*
- *ALSO:* PV takes years to give back all the electricity it can produce, while the energy investments to deploy it will largely have to be made up front

A look ahead

- EROI_{el} of PV will be dependent on EROI_{F} of fossil fuels for a long time still

- *The additional energy return from PV electricity vs. today's mostly thermal grid may afford us valuable time in our race against time after peak oil*