LCOE Derivation

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This document describes the derivation of the LCOE formula presented in the lecture. The LCOE is derived under the assumption of breaking even. The starting point to a LCOE calculation is to set the net present value of a project equal to zero.

$$NPV = 0$$

We can rewrite this as the difference between disocunted costs and discounted benefits equating zero.

$$NPV = 0 = DiscountedBenefits - DiscountedCosts$$

We can plug in the discounted sums for benefits and costs:

$$\sum_{t=1}^{T} \frac{benfit_t}{(1+r)^t} - \sum_{t=1}^{T} \frac{cost_t}{(1+r)^t} = 0$$

Rearrange:

$$\sum_{t=1}^{T} \frac{benfit_t}{(1+r)^t} = \sum_{t=1}^{T} \frac{cost_t}{(1+r)^t}$$

$$1 = \frac{\sum_{t=1}^{T} \frac{cost_t}{(1+r)^t}}{\sum_{t=1}^{T} \frac{benfit_t}{(1+r)^t}}$$

Next, we can plug in for each periods costs and benefits. On the cost side, we plug in I_t for investment costs in period t O_t for operating costs in period t, F_t for fuel costs in period t and D_t for waste costs in period t. On the benefit side, we plug in PE_t for the price of energy in period t and MWh_t is the production of electricity in period t.

$cost_t = I_t + O_t + F_t + D_t$

$benefit_t = PE_t * MWh_t$

This gives the new formula:

$$1 = \frac{\sum_{t=1}^{T} \frac{I_t+O_t+F_t+D_t}{(1+r)^t}}{\sum_{t=1}^{T} \frac{PE_t*MWh_t}{(1+r)^t}}$$

In order to compute the levelized cost for energy, we assume that the energy price is constant over time in order to have one average number for the energy

price: $PE_t = LCOE$. Therefore, we can pull it out of the sum and solve the equation for the levelized cost of energy:

$$1 = \frac{\sum_{t=1}^{T} \frac{I_t+O_t+F_t+D_t}{(1+r)^t}}{\sum_{t=1}^{T} \frac{LCOE*MWh_t}{(1+r)^t}}$$

$$1 = \frac{\sum_{t=1}^{T} \frac{I_t+O_t+F_t+D_t}{(1+r)^t}}{LCOE * \sum_{t=1}^{T} \frac{MWh_t}{(1+r)^t}}$$

$$LCOE = \frac{\sum_{t=1}^{T} \frac{I_t+O_t+F_t+D_t}{(1+r)^t}}{\sum_{t=1}^{T} \frac{MWh_t}{(1+r)^t}}$$

By only looking at the final formula for the LCOE, one might try to interpret the discounting of the MWh. In fact is is the remaining part of the benefits that is discounted after the constant price (LCOE) has been taken out of the sum. The "discounting" is just a derived result without meaning as for monetary values.