LEVELIZED COST OF ELECTRICITY: CAN ITS ACCURACY BE IMPROVED?

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Overview

- LCOE (Levelized Cost of Electricity) indicator is commonly used when designing an electricity generation plant, to compare the different technologies available.
- Referred to the date the plant enters into service, but calculated over its entire useful life.
- LCOE: average cost that will be incurred to produce one kilowatt-hour of electricity.
- Since production is spread over the coming years, it is discounted, or “brought back” to the present.

Overview

“Simple” definition of LCOE:

LCOE= (Total discounted costs)/(Total discounted energy)   (1)

Overview

Formal definition of LCOE

$$LCOE = \frac{I_0 + \sum_{t=1}^{n} \frac{C_t}{(1+r)^t}}{\sum_{t=1}^{n} \frac{E_t}{(1+r)^t}} \qquad (2)$$

- I_0: initial investment, in euro cents;
- Ct: total cost, in euro cents, that will be incurred in year t of the plant's useful life;
- Et: amount of electricity produced in year t, in kWh;
- r: real discount rate, in percent;
- n: useful life of the plant, in years.

Overview

- To perform the discounting, an appropriate discount rate is used.
- Applying a discount rate to sums of money is a common operation;
- However, extending this operation to quantities of energy requires some clarification.

Overview

- A discount rate is usually applied to assets (typically money) that are intended to be returned.
  - Person A lends Person B $100;
  - after a year, Person B returns the $100 to Person A and adds $3 for the trouble.
- However, those who purchase energy do not usually intend to return it: they use it to meet their own needs and therefore consume it permanently.

Overview

- ‘Net Metering’ (NM) may seem to be an exception

- NM system: a user system (a hotel, a factory, etc.) that covers part of its electricity needs thanks to a (small) electric generator with which it is equipped.

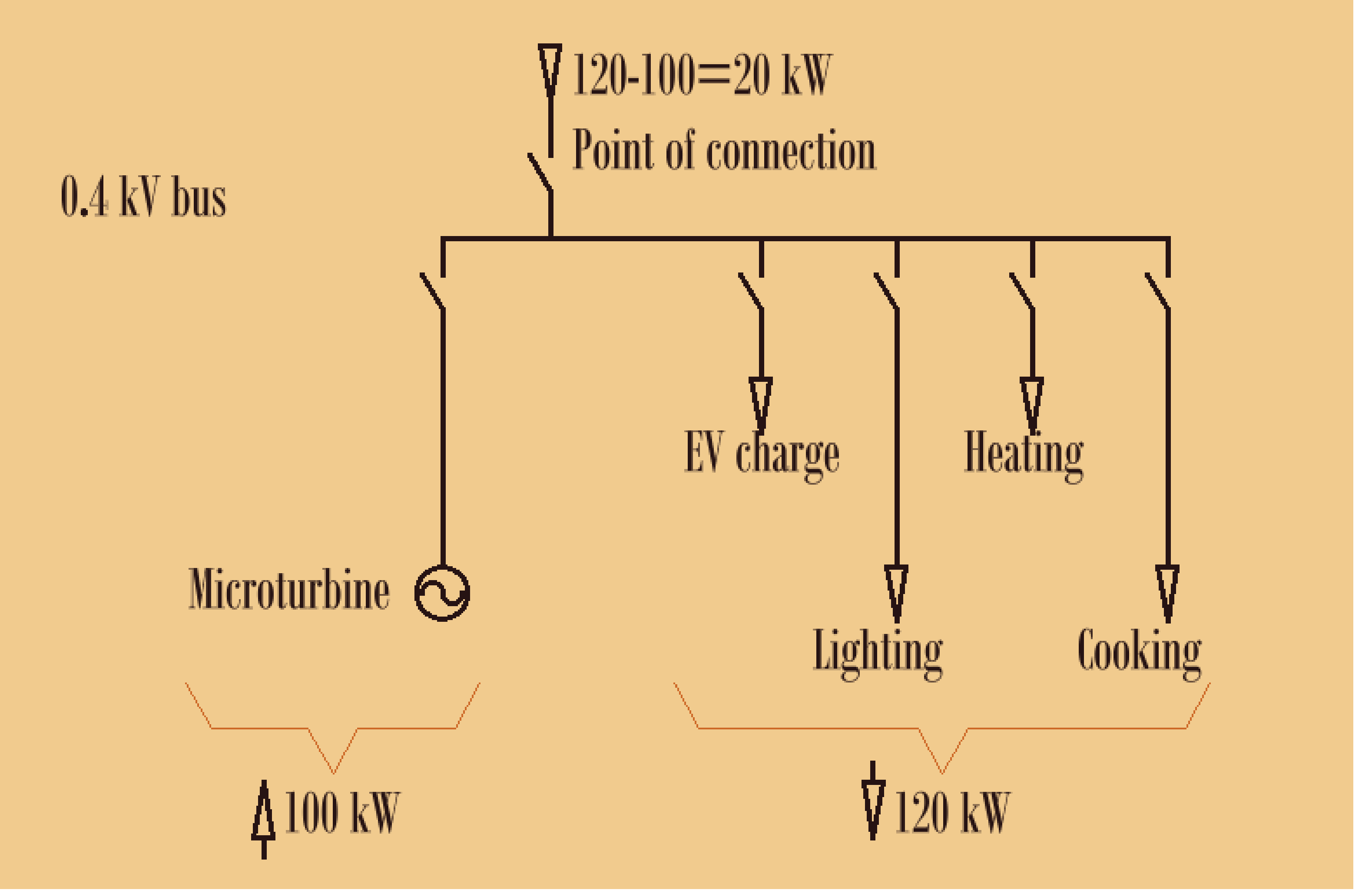
Overview

- In times of high electrical demand, the NM system draws energy from the grid, thus supplementing the generator's insufficient production.

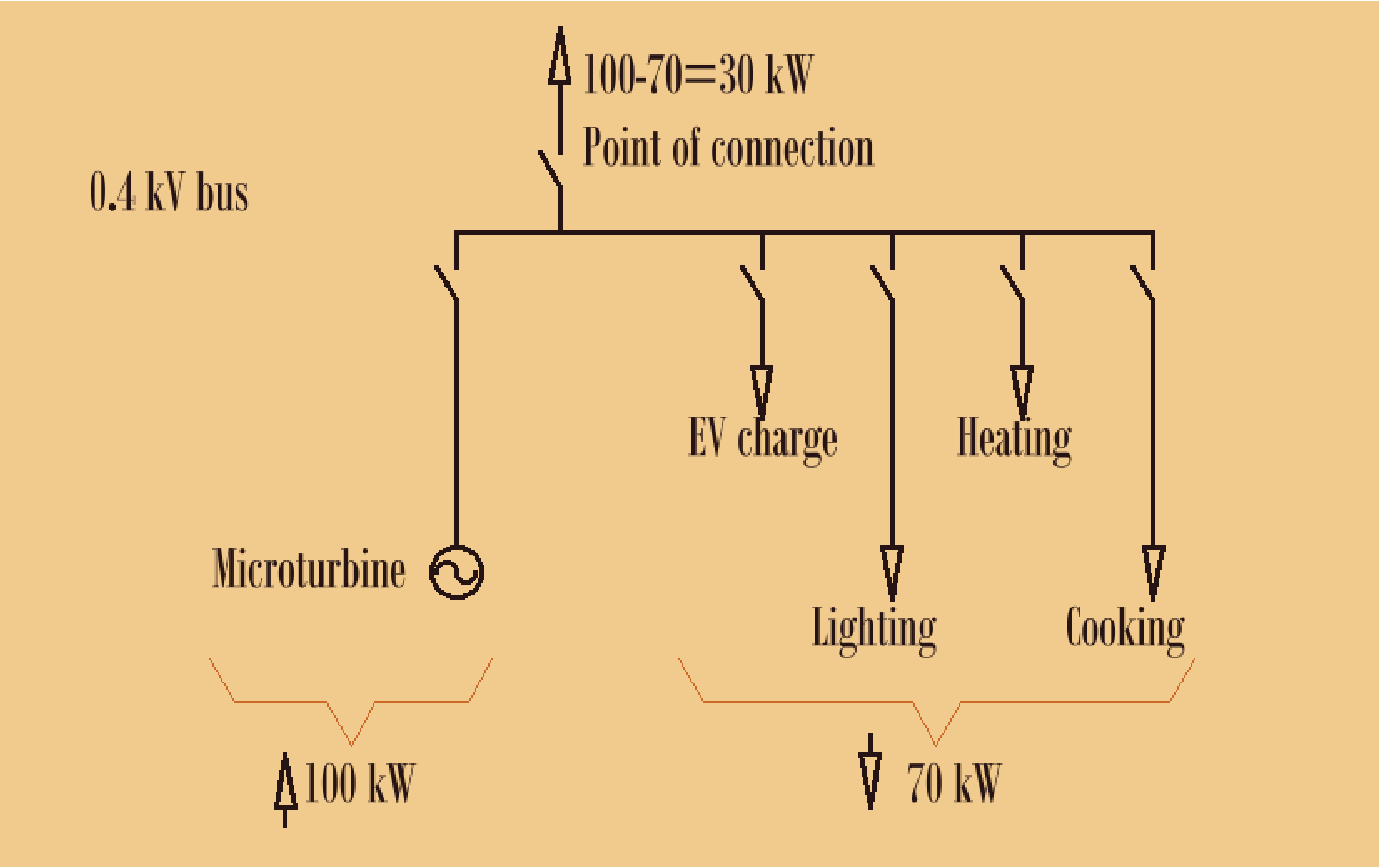
- As the load decreases, the withdrawal from the grid decreases until it is zero:

- the generator is now able to meet the entire demand; overproduction may occur.

Overview


120-100=20 kW
Point of connection
0.4 kV bus
EV charge
Heating
Microturbine
Lighting
Cooking
100 kW
120 kW

Overview



100-70=30 kW
Point of connection
0.4 kV bus
EV charge
Heating
Microturbine
Lighting
Cooking
100 kW
70 kW

Overview

- In case of overproduction, the excess energy produced is transferred to the grid.
- Energy withdrawn during the previous phase is “returned” to the grid, in whole or in part.

Overview

- NM: an exception to the ordinary purchase of energy by users?
- NM: an opportunity to compensate for the withdrawal from the grid not with money, but with other energy?
- On closer inspection, this is not the case.

Overview

- Withdrawals and returns between the grid and the load are determined by the capricious needs of the NM system.

- Often rapid and sometimes irregular, this exchange of energy is hardly suited to calculations involving a discount rate.

- Not surprisingly, in NM Italian regulations, economic transactions between the grid and the NM system are settled by transfers of money, not additional energy.

Overview

- Applying a discount rate implies that the use of a certain asset can be deferred, albeit with a certain sacrifice:

- the discount rate serves to estimate the extent of this sacrifice, in order to compensate for it with greater future use of that asset. This works very well with money.

- However, the consumption of energy is determined by immediate needs, which tolerate only very short delays, if any (a few hours at most).

- Delays of months or years, such as those that justify (in other domains) the use of a discount rate, are unrealistic.

Overview

- But above all:
  - *how will greater consumption compensate me, in a year's time, for today's reduced consumption?*
  - *Will I overcool my apartment next summer to forget the heat I am suffering today?*

Overview

- A ‘discount rate’ assumes that the good in question is capable of becoming available in ever-increasing quantities:

- *The good is capable of ‘**multiplying**’.*

Overview

- Back to the example: what will Person B do with the hundred dollars they have borrowed?
  - *Typically, they will start a business, and thus make a profit:*
  - *after a year, they will have earned at least 103 dollars (actually even more), and pay their debt to Person A.*
  - *Person A's original hundred dollars are now 103.*

Overview

- <u>*This can hardly occur with electricity:*</u>

- Person X produces and supplies Person Y with 100 kilowatt-hours;

- Person Y will probably use them to meet their own needs (to cool a room using a heat pump, or to operate a machine tool in a factory, etc.);

- the **100 kWh**, far from becoming 103, will be **consumed** and will **no longer be available**.

Overview

- It may be argued that in some cases electricity is, in fact, used to produce other energy:

- this is the case with the auxiliary services of electrical power plants.

Overview

- However, such services account for a very small percentage of a country's total electricity production.

- Furthermore, each plant usually produces energy for its own auxiliary services:
  - *No energy transfer from one entity to another.*
  - *No energy price*
  - *The very concept of LCOE does not apply.*

Overview

- In formula (2), the discount rate appearing in the numerator (dollars), is perfectly justified.

- However, when applied to the denominator (MWh), the discount rate risks introducing a potentially significant inaccuracy.

Methods

- How, then, can we modify the formula to eliminate this inaccuracy? What should we put in the denominator?

- Simply the sum of all the amounts of energy produced year by year.

- Each amount is added to that produced in the previous year to form, ultimately, the plant's total production during its useful life.

Methods

- Proceeding as described, we would obtain a new modified LCOE; in equation (3) we have indicated this with LCOEmodif (other symbols are unchanged).

$$LCOEmodif = \frac{I_0 + \sum_{t=1}^{n} \frac{C_t}{(1+r)^t}}{\sum_{t=1}^{n} E_t} \qquad (3)$$

Methods

$$LCOE = \frac{I_0 + \sum_{t=1}^{n} \frac{C_t}{(1+r)^t}}{\sum_{t=1}^{n} \frac{E_t}{(1+r)^t}} \quad (2)$$

$$LCOEmodif = \frac{I_0 + \sum_{t=1}^{n} \frac{C_t}{(1+r)^t}}{\sum_{t=1}^{n} E_t} \quad (3)$$

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Results

- **Table 1 – Comparison between LCOE values and corresponding LCOEmodif values: some examples (based on data taken from [1], tables 1, 2, 3, 9, 10)**

Tecnology	CAPEX (Euro/kW)	OPEX fixed (Euro/kW)	OPEX var (Euro/kWh)	Rated capacity (kW)	Useful life duration	Real discount rate (WACC, %)	Performance decay (%/year)	Full load operation (equivalent hours/year)	LCOE (cent/kWh)	LCOEmodif (cent/kWh)
PV	1.000,00	26,00	0,00	25,00	30,00	5,10	0,25	1.380,00	*6,86*	*3,51*
PV	1.000,00	26,00	0,00	25,00	30,00	5,10	0,25	1.680,00	*5,63*	*2,88*
PV	1.000,00	26,00	0,00	25,00	30,00	5,10	0,25	1.790,00	*5,29*	*2,70*
PV	700,00	13,30	0,00	1.500,00	30,00	5,40	0,25	1.380,00	*4,55*	*2,25*
PV	700,00	13,30	0,00	1.500,00	30,00	5,40	0,25	1.680,00	*3,74*	*1,85*
PV	700,00	13,30	0,00	1.500,00	30,00	5,40	0,25	1.790,00	*3,51*	*1,73*
Wind onshore	1.300,00	39,00	0,0080	2.000,00	25,00	7,00	0,00	3.000,00	*5,82*	*2,71*
Wind offshore	2.200,00	70,00	0,0080	5.000,00	25,00	5,40	0,00	4.000,00	*6,61*	*3,58*
Wind onshore bis	1.300,00	32,00	0,0070	2.000,00	25,00	7,00	0,00	3.000,00	*5,49*	*2,56*
Wind offshore bis	2.200,00	39,00	0,0080	5.000,00	25,00	5,40	0,00	4.000,00	*5,84*	*3,16*

Results

- Differences between LCOE and LCOEmodif vary from case to case.

- However, it seems obvious that LCOE, in its current form, leads to a significant overestimation of energy production costs.

Conclusions

- Given their magnitude, the differences between LCOE and LCOEmodif suggest that the question of a possible "reform" of LCOE—not necessarily in the way we propose—is not purely academic.

- LCOE can directly influence the spread of renewable energy sources. No small matter.

References

Assessments in this presentation are based solely on the author's personal opinions.

[1] Christoph Kost, Paul Müller, Jael Sepúlveda Schweiger, Verena Fluri, Jessica Thomsen, **Levelized Cost of Electricity - Renewable Energy Technologies,** *Fraunhofer Institute for Solar Energy Systems ISE, July 2024.*

Thank you for your attention

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