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Letter to Editor

Letter to Editor: Rebuttal to “Some comments to the paper ‘Energy, exergy and sustainability analyses of hybrid renewable energy based hydrogen and electricity production and storage systems: Modeling and case study’”

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This rebuttal form (as a Letter to Editor) is prepared by the authors of paper: “Energy, exergy and sustainability analyses of hybrid renewable energy based hydrogen and electricity production and storage systems: Modeling and case study (http://dx.doi.org/10.1016/j.applthermaleng.2012.04.026)” for the “**Letter to Editor” of “Some comments to the paper ‘Energy, exergy and sustainability analyses of hybrid renewable energy based hydrogen and electricity production and storage systems: Modeling and case study’”** by M. Calderón, A.J. Calderón, A. Ramiro, J.F. González, I. González (http://dx.doi.org/10.1016/j.applthermaleng.2013.03.024).

Dear Editor-in-Chief,

Many thanks for conveying this letter to the editor to us. It is really nice to see a large group of people from the same institute has worked on our paper and provided some comments. Their immense efforts deserve warm thanks from us.

One point of citing Dincer et al., rather than the correct order of Caliskan et al., makes us wonder about the motivation to prepare such a letter! Anyway, we have addressed all issues one by one as given below:

1) One of the comments of Calderon et al. (http://dx.doi.org/10.1016/j.applthermaleng.2013.03.024): (See Fig. 1)

R1. This is a well-known energy balance equation, which shows the conservation of energy. If this equation is rearranged, the following is obtained:

$$\dot{E}n_{\mathbf{WT,air,kin}} = \dot{E}n_{\mathbf{WT,out,usf}} + \dot{E}n_{\mathbf{WT,loss}} \quad (1)$$

where left side of the equation is energy input, while the right side is energy output. This equation (energy input = energy output) is the first law of thermodynamics. Here, $\dot{E}n_{WT,out,usf} + \dot{E}n_{WT,loss}$ can be considered as the net energy output rate and may be shown as “$\Delta\dot{E}n_{WT,out}$”.

2) One of the comments of Calderon et al. (http://dx.doi.org/10.1016/j.applthermaleng.2013.03.024): (See Fig. 2)

To perform the energy analysis of the turbine, the work implements an energy balance for it given by the following expression:

$$\dot{E}n_{\mathbf{WT,air,kin}} - \dot{E}n_{\mathbf{WT,out,usf}} - \dot{E}n_{\mathbf{WT,loss}} = 0 \quad (1)$$

where, according to the authors, "$\dot{E}n_{\mathbf{WT,air,kin}}$", "$\dot{E}n_{\mathbf{WT,out,usf}}$" and "$\dot{E}n_{\mathbf{WT,loss}}$" are the kinetic energy rate of the air, the net useful energy output rate, and the energy loss rate for the wind turbine, respectively.

Fig. 1. First comment of Calderon et al. (http://dx.doi.org/10.1016/j.applthermaleng.2013.03.024).

http://dx.doi.org/10.1016/j.applthermaleng.2013.03.065

The kinetic energy rate of the air is given by the expression:

$$\dot{E}n_{WT,air,kin} = \frac{1}{2}\dot{m}_{WT,a}\, v_{wind,in}^{2} \qquad (2)$$

where "$\dot{m}_{WT,a}$" is the mass flow rate of the air and "$v_{wind,in}$" is the inlet wind velocity for the wind turbine.

The net useful energy output rate is given by the product of the characteristic voltage and the current of the wind turbine:

Fig. 2. Second comment of Calderon et al. (http://dx.doi.org/10.1016/j.applthermaleng.2013.03.024).

V = linear speed of the wind, meter/sec

$$P_{mech} = 0.5\rho A C_p V^3 \qquad (2)$$

where:

ρ = air density (kg/m³)

A = swept area (m²)

C_p = coefficient of wind turbine

V = wind velocity (m/s)

$$P_{TARGET} = 0.5\,\rho\, A\, C_{P_{TARGET}} \left[\frac{R}{TSR_{TARGET}}\right]^3 \omega_m^3 \qquad (3)$$

$$P_{TARGET} = K_P (RPM)^3 \qquad (4)$$

where :

P_{TARGET} = Target power (max C_p)

Cp_{TARGET} = Cp at TSR_{TARGET}

K_P = computed wind turbine data

RPM = *rotor _ speed*

high wind speed region, the pitch angle is increased to shed some of the aerodynamic power.

From Equation 1, the tip-speed ratio for a fixed speed wind turbine varies across a wide range depending on the wind speed. The power captured by the wind turbine may be written as Equation 2. From Equation 2, it is apparent that the power production

Fig. 3. "The power captured by the wind turbine" explained in Muljadi and Butterfield [1].

R2. Energy input rate a wind turbine related to its kinetic energy rate is stated by many investigators (books, journals, etc.) as follows:

- Muljadi and Butterfield [1]:

(Also, presented at the 1999 IEEE Industry Applications, Society Annual Meeting, Phoenix, Arizona October 3–7, 1999, (National Renewable Energy Laboratory, NREL, is a U.S. Department of Energy Laboratory)).

Page 2, Eq. (2) of Ref. [1]:

This equation is equal to (The power captured by the wind turbine):

$$\dot{E}n_{\mathbf{WT,air,kin}} = \frac{1}{2}\dot{m}_{\mathbf{WT,a}} V_{\mathbf{wind,in}}^2 \qquad (2)$$

where

$$m = \rho A V \qquad (3)$$

Another source:

- Khaligh and Onar [2].

Page 102, Eq. (2.1) of Ref. [2]:
It is also same as given in

- Heier [3].
- The Royal Academy of Engineering [4].

(There are many other papers, which include this very commonly used equation for a wind turbine).

3) One of the comments of Calderon et al. (http://dx.doi.org/10.1016/j.applthermaleng.2013.03.024): (See Fig. 5)

R3. About energy output rate of a wind turbine:

- Ozgener [5]

Eq.(1) of Ref. [5]:
Another source:

The other parameter is the wind speed. It is expected that wind kinetic energy rises as wind speed increases [3].

The kinetic energy of the wind can be expressed as

$$E_k = \frac{1}{2}mv^2 = \frac{1}{2}\rho V v^2 = \frac{1}{2}\rho A d v^2 = \frac{1}{2}\rho R^2 \pi d v^2, \qquad (2.1)$$

where E_k is the wind kinetic energy, m is the wind mass, v is the wind speed, ρ is the air density, A is the rotor area, R is the blade length, and d is the thickness of the "air disc"

Fig. 4. "The kinetic energy of the wind turbine" explained in Khaligh and Onar [2].