**Supplementary Information**

**Appendix A: SOFC Modeling**

The SOFC model is built based on the developed mathematical configuration; all parameters of SOFC are calculated and identified. The Engineering Equation Solver (EES) software is used to confirm the results. The equations used in this paper are from the fuel cell handbook [1] in addition to several references [2]–[6].

Table 1 contains equations related to a chemical reaction within the SOFC in addition to calculation related to water reforming, while Table 2 lists equations related to power and energy generated from the SOFC. Table 3 involves the equations related to energy balances. The material and energy balance is the basis to solve for all the unknown variables. Table 4 are the basic specifications for SOFC used in this case study.

Table 1: Chemical reactions

|  |  |  |
| --- | --- | --- |
| **Process** | **Equation** | **Eq. #** |
| Steam reformer reaction |  | ( |
| Water-gas shift reaction |  | ( |
| Electrochemical reactions at the anode |  | ( |
| Electrochemical reactions at the cathode |  | ( |
| A steam requirement for reforming reaction |  | ( |
| Generated water from the reforming reaction |  | ( |

Table 2: Power equations

|  |  |  |
| --- | --- | --- |
| **Parameter** | **Equation** | **Eq. #** |
| The cell current charge |  | ( |
| The sum of the cell current in the stack |  | ( |
| The single-cell SOFC power |  | ( |
| The energy required for reforming |  | ( |
| The total energy output from SOFC |  | ( |

Table 3: Energy balance calculations

|  |  |  |
| --- | --- | --- |
| **Component** | **Equation** | **Eq. #** |
| The fuel compressor rating () |  | ( |
| The air compressor rating () |  | ( |
| The fuel heat exchanger duty ( |  | ( |
| The air heat exchanger duty ( |  | ( |

Table 4: SOFC input parameters

|  |  |  |  |
| --- | --- | --- | --- |
| **Parameter** | **Value** | **Unit** | **Reference** |
| Operating temperature of the SOFC | 800 | °C |  |
| Fuel utilization Ratio | 90 | % | [7] |
| Converter efficiency (DC/AC) | 90 | % | [8] |
| Efficiency of voltage | 75 | % |  |
| Density of current | 2500 | A/m2 | [9] |
| Single-cell area | 35 | cm2 | [8] |
| Quantity of cells in series | 150 |  | [8] |
| Quantity of cells in parallel | 150 |  | [8] |

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