Supplement materials for the paper “*Cost-Effective Scheduling of a Hydrogen-based Iron and Steel Plant Supplied by a Grid-assisted Renewable Energy System*”

1. **Equipment parameters**

The technical specifications of each proton exchange membrane (PEM) electrolyser array, corresponding to the Siemens product 'Silyzer 300' [1], are provided in Table 1. To ensure the required quantity of hydrogen (H2) for the ironmaking stage, 25 PEM electrolysis arrays are stacked.

Table I

Technical Parameters of the PEM Electrolyser

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Item | Nominal power | Power adjustable range | Operational efficiency | H2 production rate |
| Note | 17.5 MW | 40%-100% | 90% | 335 kg/hour |

The specifications of each H2 tank (HT) unit, as detailed in Table II, correspond to the GKN HYDROGEN product 'HY2MEGA' [2]. Ten HT units are stacked to form an HT system for increased storage capacity. The operating range of the HT system is managed to prevent any degradation of lifespan caused by excessive release and storage.

Table II

Technical Parameters of Hydrogen Tank

|  |  |  |  |
| --- | --- | --- | --- |
| Item | Storage capacity | Charging/Release flow rate | Operational capacity range |
| Note | Max. 250 kg | Max. 105 kg H2 /hour | 10%-90% |

The technical specifications of the DRI shaft furnace, pertain to the MIDREX shaft furnace introduced by [3]. The technical parameters of the EAF, listed in Table III, are associated with the DANIELI ZEROBUCKET EAF technology [4].

Table III

Technical Parameters of Electric Arc Furnace

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Item | Nominal power | Equipment efficiency | Liquid steel per batch | Processing time |
| Note | 228 MW | 80% | 240 tonne | 60 min |

Based on stoichiometric principles, the mass dependencies of the H2-DRI-EAF process are given in Table IV.

Table IV

Stoichiometric Balance of each Process

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Process | Input | | Output | |
| Mass | Amount | Mass | Amount |
| Hydrogen production | Water | 9 tonne | Hydrogen | 1 tonne |
| Direct reduction | Hydrogen | 0.051 tonne | Direct reduced iron | 1 tonne |
| EAF steelmaking | Direct reduced iron | 1 tonne | Liquid steel | 1 tonne |

1. **Parameter settings**

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| --- |
| **Parameters** |
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**References:**

[1] Siemens-Energy, ‘Green hydrogen production’. Accessed: Jun. 23, 2024. [Online]. Available: https://www.siemens-energy.com/global/en/home/products-services/product-offerings/hydrogen-solutions.html

[2] GKN Hydrogen, ‘Hydrogen Storage All-In-One-Solutions’, GKN Hydrogen. Accessed: Jun. 23, 2024. [Online]. Available: https://www.gknhydrogen.com/product/

[3] MIDREX Technologies, Inc., ‘Direct from MIDREX’, Direct from MIDREX. Accessed: Jun. 23, 2024. [Online]. Available: https://www.midrex.com/tech-article/midrex-direct-reduction-plants-2022-operations-summary/

[4] DANIELI, ‘Electric Arc Furnaces’. Accessed: Jun. 23, 2024. [Online]. Available: https://www.danieli.com/en/products/products-processes-and-technologies/electric-arc-furnace\_26\_83.htm