

# VALUTAZIONE DEL CICLO DI VITA DI UN IMPIANTO EOLICO OFFSHORE GALLEGGIANTE: UN CASO STUDIO ITALIANO

## MATERIALE SUPPLEMENTARE

**SM.1.**

**MIX**

**ENERGETICO**

**ITALIANO**

**Tabella SM.1.** Produzione di elettricità per fonte energetica in Italia (mix elettrico nazionale)

| Anno | Fonte di energia |          |              |                  |         |               |            |                     |        |             |
|------|------------------|----------|--------------|------------------|---------|---------------|------------|---------------------|--------|-------------|
|      | Carbone          | Petrolio | Gas naturale | Bio-combustibili | Rifiuti | Idroelettrico | Geotermico | Solare fotovoltaico | Eolico | Altre fonti |
| 2018 | 11%              | 4%       | 44%          | 6%               | 2%      | 17%           | 2%         | 8%                  | 6%     | 0%          |
| 2020 | 5%               | 3%       | 49%          | 6%               | 2%      | 17%           | 2%         | 9%                  | 7%     | 0%          |

Fonte: IEA, 2022.

## SM.2. Dettagli sull'analisi di inventario

**Tabella SM.2.** Dimensioni e masse dei principali componenti della turbina e della piattaforma galleggiante di riferimento

| <b>Turbina eolica di riferimento da 15 MW</b>     | <b>U.d.m.</b> | <b>Valore</b> |
|---|---------------|---------------|
| Diametro del rotore                               | m             | 240           |
| Altezza della torre                               | m             | 150           |
| Massa della torre                                 | t             | 1.263         |
| Massa della navicella                             | t             | 615           |
| Massa del rotore                                  | t             | 376           |
| Massa totale della turbina                        | t             | 2.254         |
| <b>IEA VoltturnUS-S Piattaforma semi-sommersa</b> | <b>U.d.m.</b> | <b>Valore</b> |
| Massa della struttura di acciaio                  | t             | 4.014         |
| Zavorra: materiale inerte                         | t             | 2.540         |
| Zavorra: Materiale fluido                         | t             | 11.300        |
| Massa totale della piattaforma                    | t             | 17.854        |

Fonti: Gaertner et al, 2020 e Allen et al, 2020.

**Tabella SM.3.** Frazioni in massa dei materiali della torre (Raadal et al, 2014) e del rotore (Wang et al, 2019)

|               | Acciaio (basso legato) | Acciaio cromato | Ghisa | Plastica rinforzata con fibre di vetro | Alluminio | Rame | Plastica (PET) | Componenti elettronici per le unità di controllo | Olio |
|---------------|------------------------|-----------------|-------|--|-----------|------|----------------|--|------|
| <b>Torre</b>  | 93%                    |                 |       |  | 2%        | 1%   | 2%             | 2%   | 1%   |
| <b>Rotore</b> |                        | 21%             | 22%   | 57%                                    |           |      |                |  |      |

**Tabella SM.4.** Frazioni in massa dei materiali della navicella, con sistema di trasmissione diretta (*direct-drive*)

| <b>Componenti della navicella – frazioni in massa</b> |                        |                 |       |                    |                    |      |                                |  |
|---|------------------------|-----------------|-------|--------------------|--------------------|------|--------------------------------|--|
|   | Acciaio (basso legato) | Acciaio cromato | Ghisa | Acciaio rinforzato | Magneti permanenti | Rame | Trasformatore a bassa tensione | Componenti elettronici per le unità di controllo |
| <b>Componenti navicella</b>                           | 67%                    |                 |       |                    |                    |      | 31%                            | 2%   |
| <b>Generatore direct-drive</b>                        |                        |                 | 49%   | 42%                | 7%                 | 2%   |                                |  |
| <b>Comandi di imbardata</b>                           | 5%                     | 95%             |       |                    |                    |      |                                |  |

Fonte: Gaertner et al, 2020

**Tabella SM.5.** Inventario dei materiali per i cavi sottomarini di interconnessione a 66 kV in corrente alternata (*Medium Voltage Alternate Current, MVAC*). Cavi con isolamento estruso, tripolari e alluminio come conduttore, di sezione 120 mm<sup>2</sup> o 500 mm<sup>2</sup>.

I dati in corsivo sono stati estrapolati: la stima della massa del conduttore e delle frazioni in massa dei materiali sono state assunte da (Schleisner, 1999 e Burger and Bauer, 2007).

| <b>Sezione del conduttore</b>                                       | <b>120 mm<sup>2</sup></b> |             | <b>500 mm<sup>2</sup></b> |             |
|---|---------------------------|-------------|---------------------------|-------------|
|   | kg/m                      |             | kg/m                      |             |
| Ipotesi sul peso totale   | <b>20</b>                 | <b>100%</b> | <b>50</b>                 | <b>100%</b> |
| <b>Richiesta di materie prime</b>                                   |                           |             |                           |             |
| Alluminio   | <i>0,97</i>               | <i>4%</i>   | <i>4</i>                  | <i>8%</i>   |
| Polietilene reticolato (XLPE) o polivinilcloruro (PVC) <sup>1</sup> | <i>5</i>                  | <i>25%</i>  | <i>11</i>                 | <i>22%</i>  |
| Piombo  | <i>6,4</i>                | <i>32%</i>  | <i>16</i>                 | <i>32%</i>  |
| Acciaio galvanizzato  | <i>7,6</i>                | <i>38%</i>  | <i>19</i>                 | <i>38%</i>  |

<sup>1</sup> Soprattutto XLPE e una minima parte come PVC

**Tabella SM.6.** Inventario dei materiali per la fabbricazione e la manutenzione dei cavi sottomarini HVDC (*High Voltage Direct Current*) isolati a 500 kV, impieganti per l'export dell'energia generata. Cavi a massa impregnata, ciascuno con due nuclei di conduttore (rame) di sezione pari a 1.000 mm<sup>2</sup>. I dati in corsivo sono stati estrapolati: la stima della massa del conduttore e delle frazioni in massa dei materiali sono state assunte da (Jorge et al, 2012).

| <b>Richiesta di materie prime</b> | <b>kg/m</b> |
|-----------------------------------|-------------|
| Rame                              | 17,8        |
| Carta                             | 6,1         |
| Olio isolante                     | 4,7         |
| Piombo                            | 17,2        |
| Acciaio                           | 19,2        |
| Bitume                            | 0,73        |
| Polipropilene (PP)                | 2,2         |
| <b>Totale</b>                     | <b>68,6</b> |

**Tabella SM.7.** Inventario dei materiali per la fabbricazione e la manutenzione dei cavi terrestri HVDC (*High Voltage Direct Current*) isolati a massa impregnata (380 kV). Fonte: (Jorge et al, 2012).

| <b>Richiesta di materie prime</b> | <b>kg/m</b> |
|-----------------------------------|-------------|
| Rame                              | 14,7        |
| Carta                             | 5           |
| Olio isolante                     | 3,9         |
| Piombo                            | 14,2        |
| Acciaio                           | 3,4         |
| Polietilene (PE)                  | 2,6         |
| <b>Totale</b>                     | <b>43,8</b> |

**Tabella SM.8.** Distanze aggiuntive assunte per il trasporto dei componenti in Sicilia

| <b>Mezzo di trasporto</b> | <b>Unità</b> | <b>Componenti del parco eolico</b> |                          |                    |                                |
|---------------------------|--------------|------------------------------------|--------------------------|--------------------|--------------------------------|
|                           |              | Turbine <sup>1</sup>               | Piattaforma galleggiante | Catene di ormeggio | Trasformatore ad alta tensione |
| Automezzo                 | km           | 120                                | 120                      | 100                | 150                            |
| Nave                      | km           | 4.000                              | 4.000                    | 3.200              | 800                            |

<sup>1</sup> Distanze per raggiungere la Sicilia, calcolate come media, ipotizzando la produzione dei componenti in Europa (Germania, Danimarca o Spagna) e assunte per l'intera struttura della turbina; da aggiungere alle assunzioni tratte da Razdan and Garret (2019).

**Tabella SM.9.** Assunzioni per la fase di installazione in mare

|     |                | <b>Tipo di imbarcazione</b>           | <b>Numero di imbarcazioni</b> | <b>Giorni di lavoro</b> | <b>Consumo di olio combustibile (t/d)<sup>2</sup></b> |
|-----|----------------|---------------------------------------|-------------------------------|-------------------------|---|
| OTM | Turbina eolica | Rimorchiatore                         | 2                             | 1                       | 18.5  |
|     |                | Anchor Handling Tug and Supply (AHTS) | 1                             | 1                       | 37.5  |
|     |                | Platform Support Vessel (PSV)         | 1                             | 1                       | 18.5  |
|     |                | Fast Supply Vessel                    | 1                             | 1                       | 9   |

|  | <b>Tipo di imbarcazione</b> | <b>Numero di imbarcazioni</b> | <b>Giorni di lavoro</b> | <b>Consumo di olio combustibile (t/d)<sup>2</sup></b> |
|--|-----------------------------|-------------------------------|-------------------------|---|
|  | Imbarcazione con gru        | 1                             | 11                      | 4   |

<sup>2</sup> La conversione da (L/h) a (kg/h) è stata fatta assumendo Heavy Fuel Oil (HFO) con densità pari a 0,983 kg/L come in (Arvesen et al, 2013)

### SM.3. Scenari assunti per il fine vita

**Tabella SM.10.** Assunzioni sul trattamento a fine vita dei singoli materiali

| <b>Materiale</b>                       | <b>Gestione del rifiuto</b>   | <b>Processi (ecoinvent 3.7.1 dataset)</b>  |
|--|---|--|
| Acciaio                                | 10% discarica   | Scrap steel {Europe without Switzerland}  treatment of scrap steel, inert material discarica   Cut-off, U  |
|  | 90% riciclo   | <i>Approccio EPD: non si include il trattamento di riciclo nei confini del sistema</i>   |
| Alluminio                              | 10% discarica   | Waste aluminium {CH}  treatment of, sanitary landfill   Cut-off, U   |
|  | 90% riciclo   | <i>Approccio EPD: non si include il trattamento di riciclo nei confini del sistema</i>   |
| Rame                                   | 10% discarica   | HP discarica come l'acciaio (no specific data)   |
|  | 90% riciclo   | <i>Approccio EPD: non si include il trattamento di riciclo nei confini del sistema</i>   |
| Ferro e ghisa                          | 90% riciclo   | <i>Approccio EPD: non si include il trattamento di riciclo nei confini del sistema</i>   |
|  | 10% discarica   | HP discarica come l'acciaio (no specific data)   |
| Plastica                               | 100 % incenerimento   | Incenerimento PE - Italia no recupero energetico <sup>23</sup><br>(alternative EI: Waste polyethylene {CH}  treatment of, municipal incineration   Cut-off, U) |
| Plastica rinforzata con fibre di vetro | Scenario base:<br>incenerimento vetro 60% +<br>incenerimento plastica 40% | Waste glass {CH}  treatment of, municipal incineration   Cut-off, U<br><br>Waste plastic, mixture {CH}  treatment of, municipal incineration   Cut-off, U      |
|  | Scenario alternativo:<br>riciclo 100%                                     | <i>Approccio EPD: non si include il trattamento di riciclo nei confini del sistema</i>   |
|  |   |  |
| RAEE                                   | 100% trattamento e smaltimento  | Electronics scrap from control units {RER}  treatment of   Cut-off, U  |
| Cavi                                   | 100% selezione e riciclo  | Used cable {GLO}  treatment of   Cut-off, U  |
| Olio lubrificante                      | 100% incenerimento di rifiuti pericolosi                                  | Waste mineral oil {Europe without Switzerland}  treatment of waste mineral oil, hazardous waste incineration   Cut-off, U                                      |

## SM.4. Analisi di inventario dettagliata

Tabella SM.11. Dati di inventario dettagliati

| Level  | Component                        | Number | Weight (t) | Processes   | Note      |
|--------|----------------------------------|--------|------------|---|-----------|
| 1.     | Wind turbine IEA-15-MW-RWT       | 190    |            |   |           |
| 1.1.   | Tower                            | 1      | 1262       | Dataset created based on mass fractions                                   |           |
| 1.2.   | Nacelle direct drive             | 1      | 631        | Dataset created based on mass fractions                                   |           |
| 1.3.   | Rotor                            | 1      | 377        | Dataset created based on mass fractions                                   |           |
| 1.3.1. | Blade                            | 3      | 64         |   |           |
| 1.3.2. | Hub                              | 1      | 185        |   |           |
| 2.     | Floating substructure            | 190    |            |   |           |
| 2.1.   | Semi-submersible platform: steel | 1      | 4014       | Steel, low-alloyed, hot rolled {GLO}   market for   Cut-off, U            |           |
| 2.1.   | Ballast (fixed)                  | 1      | 2540       | iron ore concentrate {GLO}   market for iron ore concentrate   Cut-off, U |           |
| 2.2.   | Ballast (fluid)                  | 1      | 11300      | Water, unspecified natural origin, UN-SEASIA                              |           |
| 3.     | Mooring system                   | 190    |            |   |           |
| 3.1.   | Mooring chain                    | 3      | 582        | See EPD data  |           |
| 3.2.   | Anchor                           | 3      | N.A.       |   | Neglected |

| Level  | Component                             | Length (km) | Weight (kg/m) | Processes   | Note |
|--------|---------------------------------------|-------------|---------------|---|------|
| 4.     | Power transmission system             |             |               |   |      |
| 4.1.   | Inter-array cable 120 mm <sup>2</sup> | 388         | 20            |   |      |
| 4.1.1. | Aluminium                             |             | 0.97          | Aluminium, primary, ingot {IAI Area, EU27 & EFTA}   market for   Cut-off, U |      |
| 4.1.2. | Cross-linked polyethylene (XLPE)      |             | 5             | Polyethylene, high density, granulate {GLO}   market for   Cut-off, U       |      |
| 4.1.4. | Lead                                  |             | 6.4           | Lead {GLO}   market for   Cut-off, U  |      |
| 4.1.2. | Galvanized steel                      |             | 7.6           | Reinforcing steel {GLO}   market for   Cut-off, U                           |      |
| 4.2.   | Inter-array cable 500 mm <sup>2</sup> | 723         | 50            |   |      |
| 4.2.1. | Aluminium                             |             | 4             | Aluminium, primary, ingot {IAI Area, EU27 & EFTA}   market for   Cut-off, U |      |
| 4.2.2. | Cross-linked polyethylene (XLPE)      |             | 9             | Polyethylene, high density, granulate {GLO}   market for   Cut-off, U       |      |
|        | PVC                                   |             | 2             | Polyvinylchloride, bulk polymerised {GLO}   market for   Cut-off, U         |      |
| 4.2.3. | Lead                                  |             | 16            | Lead {GLO}   market for   Cut-off, U  |      |
| 4.2.4. | Galvanized steel                      |             | 19            | Reinforcing steel {GLO}   market for   Cut-off, U                           |      |
| 4.3.   | Submarine export HVDC cable           | 690         | 68.8          |   |      |
| 4.3.1. | Copper                                |             | 17.8          | Copper, cathode {GLO}   market for   Cut-off, U                             |      |
| 4.3.2. | Paper                                 |             | 6.1           | Kraft paper {RER}   market for kraft paper   Cut-off, U                     |      |
| 4.3.3. | Insulation oil                        |             | 4.7           | Lubricating oil {RER}   market for lubricating oil   Cut-off, U             |      |
| 4.3.4. | Lead                                  |             | 17.2          | Lead {GLO}   market for   Cut-off, U  |      |
| 4.3.5. | Steel                                 |             | 19.2          | Reinforcing steel {GLO}   market for   Cut-off, U                           |      |
| 4.3.6. | Asphalt                               |             | 0.73          | Bitumen seal {GLO}   market for   Cut-off, U                                |      |
| 4.3.7. | Polypropylene (PP)                    |             | 2.2           | Polypropylene, granulate {GLO}   market for   Cut-off, U                    |      |
| 4.4.   | Land export HVDC cable                | 75          | 43.8          |   |      |
| 4.4.1. | Copper                                |             | 14.7          | Copper, cathode {GLO}   market for   Cut-off, U                             |      |
| 4.4.2. | Paper                                 |             | 5             | Kraft paper {RER}   market for kraft paper   Cut-off, U                     |      |
| 4.4.3. | Insulation oil                        |             | 3.9           | Lubricating oil {RER}   market for lubricating oil   Cut-off, U             |      |
| 4.4.4. | Lead                                  |             | 14.2          | Lead {GLO}   market for   Cut-off, U  |      |
| 4.4.5. | Steel                                 |             | 3.4           | Reinforcing steel {GLO}   market for   Cut-off, U                           |      |
| 4.4.6. | Polyethylene (PE)                     |             | 2.6           | Polyethylene, high density, granulate {GLO}   market for   Cut-off, U       |      |

| Level  | Component                        | Number | Weight (t) | Processes   | Note      |
|--------|----------------------------------|--------|------------|---|-----------|
| 5.     | Offshore Transformer Module      | 3      |            |   |           |
| 5.1.   | Floating substructure            | 1      | 17854      |   |           |
| 2.1.   | Semi-submersible platform: steel | 1      | 4014       | Steel, low-alloyed, hot rolled {GLO}   market for   Cut-off, U            |           |
| 2.1.   | Ballast (fixed)                  | 1      | 2540       | iron ore concentrate {GLO}   market for iron ore concentrate   Cut-off, U |           |
| 2.2.   | Ballast (fluid)                  | 1      | 11300      | Water, unspecified natural origin, UN-SEASIA                              |           |
| 5.2.   | Mooring system                   | 1      | 1747       |   |           |
| 5.2.1. | Mooring chain                    | 3      | 582        | See EPD data  |           |
| 5.2.2. | Anchor                           | 3      | N.A.       |   | Neglected |
| 5.3.   | HV Transformer                   | 1      | 223        | See EPD data  |           |

| Level   | Component                              | Unit                  | Quantity | Processes   | Note  |
|---------|--|-----------------------|----------|---|---|
| 6.      | Materials processing for manufacturing |                       |          |   |   |
| 6.1.    | Steel                                  | t/GWh                 | 3.99     | Sheet rolling, steel {RER}   processing   Cut-off, U  |   |
| 6.2.    | Chromium steel                         | t/GWh                 | 0.09     | Sheet rolling, chromium steel {RER}   processing   Cut-off, U   |   |
| 6.3.    | Cast iron                              | t/GWh                 | 0.14     | Section bar rolling, steel {RER}   processing   Cut-off, U  |   |
| 6.4.    | Aluminium                              | t/GWh                 | 0.13     | Sheet rolling, aluminium {RER}   processing   Cut-off, U  |   |
| 6.5.    | Copper                                 | t/GWh                 | 0.02     | Wire drawing, copper {RER}   processing   Cut-off, U  |   |
| 6.6.    | Glass fibre reinforced plastic         | t/GWh                 | 0.03     | Injection moulding {RER}   processing   Cut-off, U  | Already included in the raw material dataset                                  |
| 6.7.    | Inter-array cables                     |                       |          |   |   |
| 6.7.1.  | Steel                                  | kg/GWh                | 13       | Wire drawing, steel {RER}   processing   Cut-off, U   |   |
| 6.7.2.  | Polyethylene PE                        | kg/GWh                | 32       | Extrusion, plastic pipes {RER}   extrusion, plastic pipes   Cut-off, U  |   |
| 6.8.    | HVDC sea cables                        |                       |          |   |   |
| 6.8.1.  | Copper                                 | kg/GWh                | 48.8     | Wire drawing, copper {RER}   processing   Cut-off, U  |   |
| 6.8.2.  | Polyethylene PE                        | kg/GWh                | 6.0      | Extrusion, plastic pipes {RER}   extrusion, plastic pipes   Cut-off, U  |   |
| 6.9.    | HVDC land cables                       |                       |          |   |   |
| 6.9.1.  | Copper                                 | kg/GWh                | 1.46     | Wire drawing, copper {RER}   processing   Cut-off, U  |   |
| 6.9.2.  | Polyethylene PE                        | kg/GWh                | 0.26     | Extrusion, plastic pipes {RER}   extrusion, plastic pipes   Cut-off, U  |   |
| 7.      | Transport of components                |                       |          |   |   |
| 7.1.    | Lorry transport of                     |                       |          | freight lorry >32t MIX ACI 2019 (prog. bevimi)  | Dataset created starting from ACI data on lorries > 32t distribution in Italy |
| 7.1.1.  | Turbine                                | (t-km)/GWh            | 638      |   |   |
| 7.1.2.  | Floating substructure                  | (t-km)/GWh            | 363      |   |   |
| 7.1.3.  | Mooring system                         | (t-km)/GWh            | 200      |   |   |
| 7.1.4.  | Transformer                            | (t-km)/GWh            | 0.42     |   |   |
| 7.2.    | Ship transport of                      |                       |          | transport, freight, sea, bulk carrier for dry goods {GLO}   market for transport, freight, sea, bulk carrier for dry goods   Cut-off, U |   |
| 7.2.1.  | Turbine                                | (t-km)/GWh            | 3703     |   |   |
| 7.2.2.  | Floating platform                      | (t-km)/GWh            | 12100    |   |   |
| 7.2.3.  | Mooring system                         | (t-km)/GWh            | 6386     |   |   |
| 7.2.4.  | Transformer                            | (t-km)/GWh            | 2.22     |   |   |
| 8.      | Assembly and installation              |                       |          |   |   |
| 8.1.    | Electricity consumption for            |                       |          |   |   |
| 8.1.1.  | Tower                                  | MWh/GWh               | 0.48     | Electricity, medium voltage {IT}   market for   Cut-off, U  |   |
| 8.1.2.  | Rotor                                  | MWh/GWh               | 0.14     | Electricity, medium voltage {IT}   market for   Cut-off, U  |   |
| 8.1.3.  | Nacelle (direct drive)                 | MWh/GWh               | 0.23     | Electricity, medium voltage {IT}   market for   Cut-off, U  |   |
| 8.1.4.  | Turbine                                | MWh/GWh               | 0.85     | Electricity, medium voltage {IT}   market for   Cut-off, U  |   |
| 8.1.5.  | Floating platform                      | MWh/GWh               | 6.73     | Electricity, medium voltage {IT}   market for   Cut-off, U  |   |
| 8.1.6.  | Mooring system                         | MWh/GWh               | 0.98     | Electricity, medium voltage {IT}   market for   Cut-off, U  |   |
| 8.1.7.  | OTMs                                   | MWh/GWh               | 0.13     | Electricity, medium voltage {IT}   market for   Cut-off, U  |   |
| 8.2.    | Diesel consumption for cranes          | MJ/GWh                | 4.11     | Diesel, burned in building machine {GLO}   market for   Cut-off, U  |   |
| 8.3.    | HVDC land cables                       | m <sup>3</sup> /GWh   | 0.42     | Excavation, hydraulic digger {GLO}   market for   Cut-off, U  |   |
| 8.4.    | Vessel's fuel consumption for          |                       |          |   |   |
| 8.4.1.  | Turbine                                | kg/GWh                | 76.9     | Heavy fuel oil {RER}   market group for   Cut-off, U   combustion emissions   |   |
| 8.4.2.  | OTMs                                   | kg/GWh                | 1.74     | Heavy fuel oil {RER}   market group for   Cut-off, U   combustion emissions   |   |
| Level   | Component                              | Unit                  | Quantity | Processes   | Note  |
| 9.      | Operation and maintenance              |                       |          |   |   |
| 9.1.    | Transformation of seabed               | km <sup>2</sup>       | 2422.5   | Transformation, from seabed, unspecified  |   |
| 9.2.    | Transformation to infrastructure       | km <sup>2</sup>       | 2422.5   | Transformation, to seabed, infrastructure   |   |
| 9.3.    | Occupation of seabed                   | km <sup>2</sup> -year | 72675    | Occupation, seabed, infrastructure  |   |
| 9.4.    | Wind turbines for replacements         | #                     | 10       | Dataset created   |   |
| 9.5.    | Replacements of lubricant oil          | #/year                | 2        |   |   |
| 10.     | Dismantling                            |                       |          |   |   |
| 10.1.   | Electricity consumption                |                       |          |   |   |
| 10.1.1. | Tower                                  | MWh/GWh               | 0.48     | Electricity, medium voltage {IT}   market for   Cut-off, U  |   |
| 10.1.2. | Rotor                                  | MWh/GWh               | 0.14     | Electricity, medium voltage {IT}   market for   Cut-off, U  |   |
| 10.1.3. | Nacelle (direct drive)                 | MWh/GWh               | 0.23     | Electricity, medium voltage {IT}   market for   Cut-off, U  |   |
| 10.1.4. | Turbine                                | MWh/GWh               | 0.85     | Electricity, medium voltage {IT}   market for   Cut-off, U  |   |
| 10.1.5. | Floating platform                      | MWh/GWh               | 6.73     | Electricity, medium voltage {IT}   market for   Cut-off, U  |   |
| 10.1.6. | Mooring system                         | MWh/GWh               | 0.98     | Electricity, medium voltage {IT}   market for   Cut-off, U  |   |
| 10.1.7. | OTMs                                   | MWh/GWh               | 0.13     | Electricity, medium voltage {IT}   market for   Cut-off, U  |   |
| 10.2.   | Diesel consumption for cranes          | MJ/GWh                | 4.11     | Diesel, burned in building machine {GLO}   market for   Cut-off, U  |   |
| 10.3.   | Vessel's fuel consumption              |                       |          |   |   |
| 10.3.1. | Turbine                                | kg/GWh                | 76.9     | Heavy fuel oil {RER}   market group for   Cut-off, U   combustion emissions   |   |
| 10.3.2. | OTMs                                   | kg/GWh                | 1.74     | Heavy fuel oil {RER}   market group for   Cut-off, U   combustion emissions   |   |

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