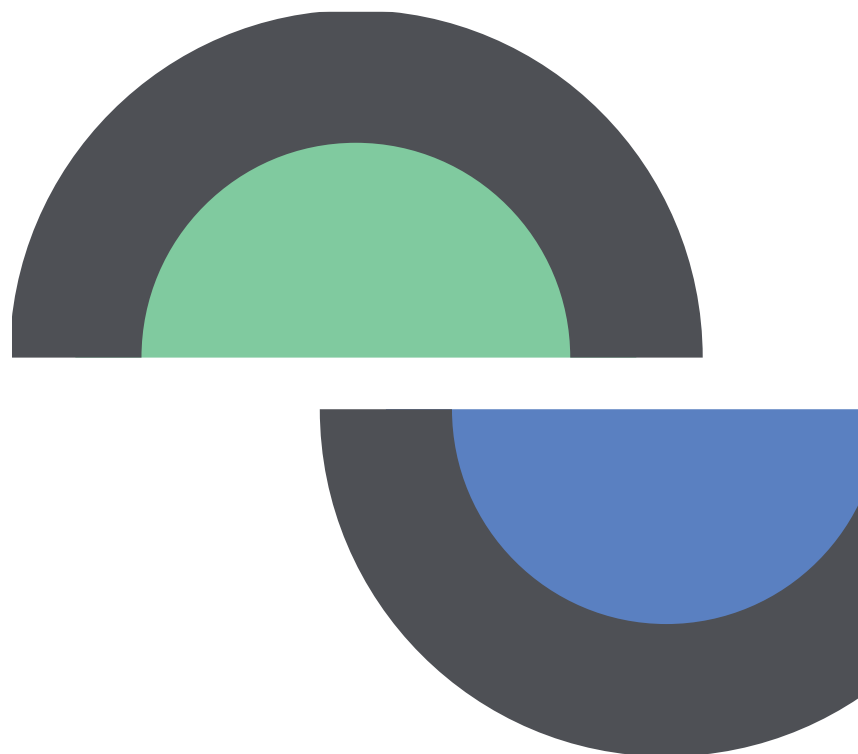


Proposal for the Extension of the LESS Rulebook Version 1.1

Stainless Steel | Electroslag Remelting (ESR) | Ingot Casting | Forging | Tube Rolling



Disclaimer

The data or calculation models contained in this rulebook and its annexes serve exclusively to enable the categorisation and classification of low-emission steel.

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Date: September 2025

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Introduction

Following the publication of the "Rulebook for the Classification System Low Emission Steel Standard (LESS)" in spring 2024, the German Steel Association (WV Stahl), together with member companies and FutureCamp Climate GmbH, began working in the summer of 2024 on proposals for expanding the rulebook to include process steps and steel grades not yet covered by the existing rulebook. This will enable the certification of a broader range of products according to the LESS standard. The proposals developed in this way support the work of the LESS aisbl in implementing the expanded rulebook.

The first version of the rulebook contains a classification system for quality steel (QST) and structural steel (BST), as well as adjustment rules for alloying elements and rolling mills. The proposals for expanding the rulebook include a

- further classification system for stainless steel

as well as suggestions for dealing with the following process steps:

- electroslag remelting (ESR)
- ingot casting
- forging
- tube tolling

1. Stainless Steel

1.1. Initial Situation

Separate thresholds are to be implemented for stainless steel within LESS. The reason for this is that the manufacturing process and the associated emissions of these steels differ significantly from the already defined grades to be represented solely using an adjustment rule. This is primarily due to the significantly higher use of alloying agents and the additional process steps for decarburisation. Therefore, based on the IEA approach, a surcharge is applied to account for these processes. This approach corresponds to the existing basic methodology used to determine the thresholds for categorisation in the LESS rulebook.

1.2. Methodology

Stainless steel is defined as a steel with a chromium content of at least 10.5 % in the finished product. The chemical composition of AISI 304 serves as the basis for the reference system.

The future classification system for stainless steel will also incorporate the Argon Oxygen Decarburisation (AOD) and Vacuum Oxygen Decarburisation (VOD) processes. As in the existing rulebook for QST and BST, the use of alloying agent will be taken into account through adjustment rules. Furthermore, the use of primary alloying agents and alloyed scrap must be appropriately reflected, since the use of scrap must not be disadvantaged compared to primary alloying agents. To integrate AOD and VOD into the steelmaking process, process gases and slag formers must be considered. Other energy inputs are generally negligible (cut-off).

The representation of the remaining processes in the steelworks is taken from the reference guide quality steel. This also includes the rolling mill, as there are no significant differences in energy or CO₂ emissions.

The data basis for determining the respective values are publicly available literature sources.

1.3. Implementation and Proposal

The alloying agents considered in addition to the existing reference plant QST are chromium and nickel. The input values for alloying agents are derived from the mean value of two literature references^{1,2} for chromium 94.23 kg/t crude steel and for nickel 28.47 kg/t crude steel.

The determination of the input quantity of the process gases argon, nitrogen and oxygen in the AOD/VOD processes is based on the AOD process, as the input quantities are higher here and it is the more frequently used process³. The VOD process, on the other hand, serves as the basis for the quantity of slag formers used. This does not disadvantage the AOD process, as the additional use of slag formers can be represented using the existing adjustment rules.

Another relevant difference between the production of QST and stainless steel is the reduced yield of the latter. This is due to both the additional process steps and the additional requirements. To take this into account, the total yield in the steelworks is adjusted in comparison to the existing QST reference plant. The adjustment is based on the mean value of 90.45 % from Rick et al.⁴ for the entire yield in the steel mill.

The derivation of the classification levels for stainless steel is based on the IEA approach. Identical to the procedure in the LESS rulebook, the necessary surcharge for the IEA approach is derived from the reference plant. The surcharge amounts to 400 kg CO₂/t of rolled steel for the near-zero threshold. The D to E limit for 100 % scrap input is therefore 2,250 kg CO₂/t of rolled steel. The gradient remains identical to the QST system, as the surcharge to the IEA approach is 400 kg CO₂/t rolled steel even with lower scrap input. The definition of the scrap share remains unchanged and therefore identical to the existing definition in the LESS rulebook. This means that stainless steel produced via the EAF route is usually categorised at a scrap rate of 100%, as the use of pig iron, DRI or HBI is generally dispensed with. All existing rules (e.g. adaptation rules) of the LESS rulebook also apply to the 'stainless steel' system. There is no differentiation between flat and long products. In addition to the adjusted yield in the steel mill, the existing adjustment rule for excess input in the hot rolling mill applies to all affected products. The resulting classification system is shown below.

¹ N. Arivazhagan, Surendra Singh, Satya Prakash, G.M. Reddy: Investigation on AISI 304 austenitic stainless steel to AISI 4140 low alloy steel dissimilar joints by gas tungsten arc, electron beam and friction welding. In: *Materials & Design*, Volume 32, Issue 5, May 2011, Pages 3036-3050. Online verfügbar: <https://doi.org/10.1016/j.matdes.2011.01.037>

² Liming Mou, Tiantian Bian, Shaohua Zhang, Baosheng Liu, Pengpeng Wu, Jinling Zhang, Yanchong Yu, Xinchao Wang: New sights on intergranular corrosion resistance mechanism of type 304 austenitic stainless steel by adjusting carbon contents. In: *Journal of Materials Research and Technology*, Volume 26, September–October 2023, Pages 666-680. Online verfügbar: <https://doi.org/10.1016/j.jmrt.2023.07.220>

³ Hilty, D. C., and Thomas F. Kaveney. "Stainless steel melting." *Electric furnace steelmaking* (1985): 143-159.

⁴ Total Yield (%) in Table 1 in: Carl-Johan Rick, Mikael Engholm, Kristina Beskow: Increased Stainless Steel Melt Shop Yield by Improved Converter Tap Weight Management. Veröffentlicht im Rahmen von „The 6th European Oxygen Steelmaking Conference“, Stockholm 2011. Online verfügbar: https://www.academia.edu/119115892/Increased_Stainless_Steel_Melt_Shop_Yield_by_Improved_Converter_Tap_Weight_Management

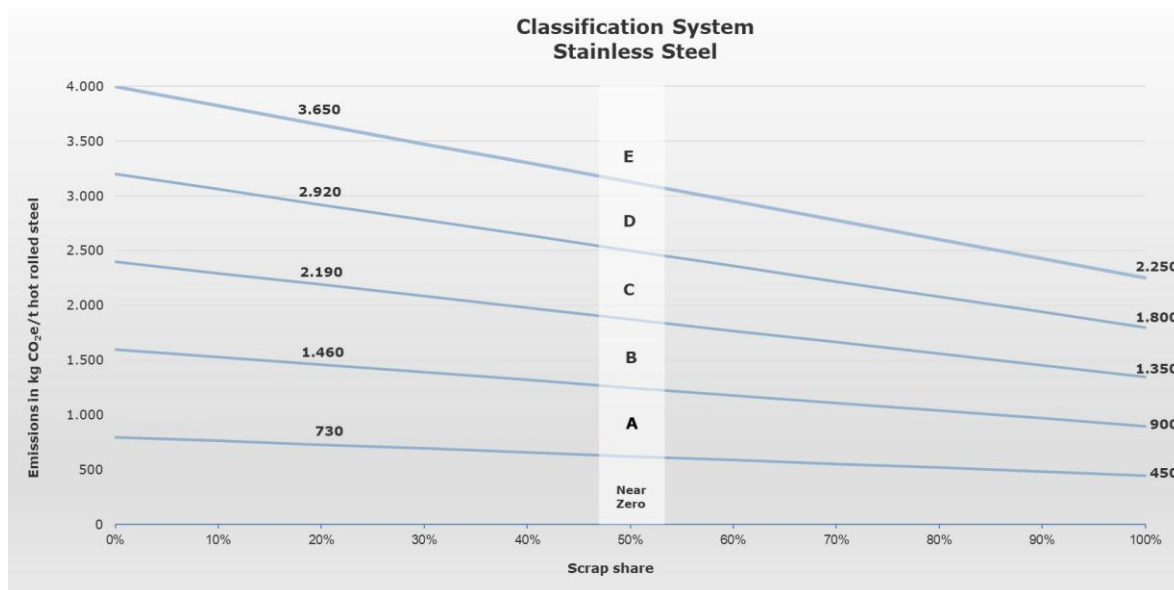


Figure 1: Slopes of the values for stainless steel

The reference installation created to check the system is categorised in the system as shown in the following diagram. This provides a comparable starting position to other systems.

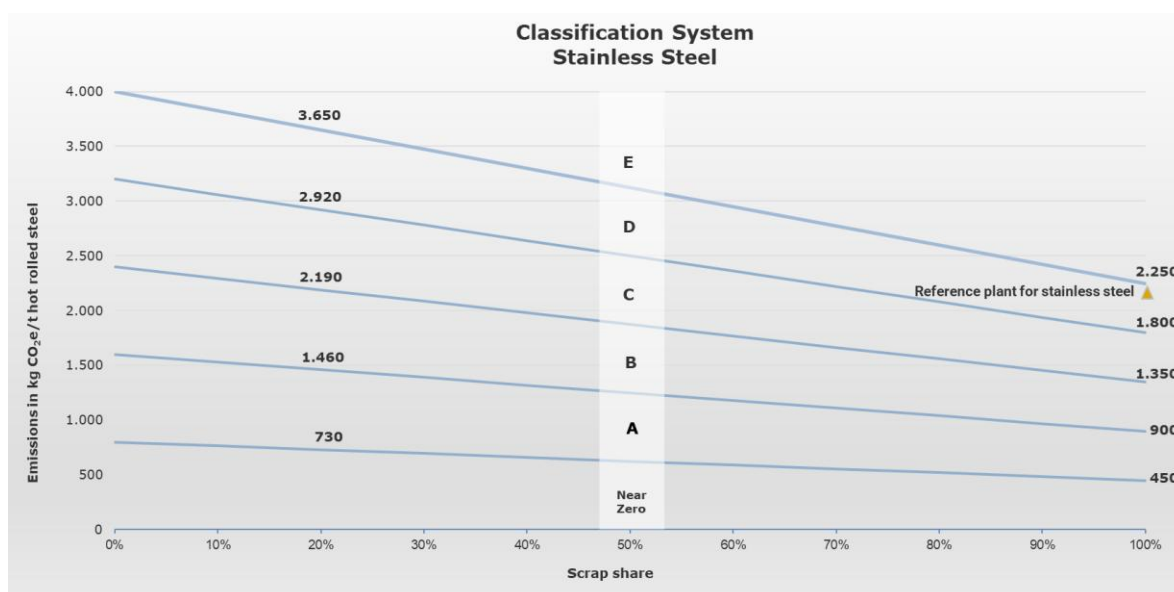


Figure 2: Level of reference plant for stainless steel in the classification system

Given that the use of alloying agents is higher for stainless steels than for quality steels and structural steels, correspondingly higher reference alloying agent emissions are defined for the ‘stainless steel’ system. These are based on the calculations of the reference plants, which were modelled by Future-Camp using literature data^{1,2,3,4}.

Reference alloy emissions Scope 3.1:
 $Em_LegRef = 1,234.8 \text{ kg CO}_{2e} / \text{t crude steel}$

The reference alloying agent emissions for stainless steel are to be applied analogously to the existing rulebook when applying the alloying agent adjustment rule.

This also applies to the special cases of the alloying agent adjustment rule. Here, the values to be applied for stainless steel are based on the above-mentioned modelling:

Special case 1:

Limit value Scope 3.1 emissions from calcium-containing input materials: **85.0** kg CO_{2e} / t crude steel

Special case 2:

Limit value carbon surplus from mass balance: **33.8** kg C/ t crude steel

Base value carbon input from primary carbon sources: **21.0** kg C/ t crude steel

Special case 3:

Excess carbon limit from mass balance: **33.8** kg C/ t crude steel

Base value carbon input from alloying agents: **7.60** kg C/ t crude steel

2. Electroslag Remelting (ESR)

2.1. Rationale

Electroslag remelting (ESR) is a common process used to produce high-purity steels for many steel grades covered by LESS. Although this process was not included in the first version of the rulebook, it is an important part of the manufacturing process in various plants and for different steel grades. For this reason, the rulebook is to be expanded to include ESR.

2.2. Methodology

As the ESR is used for different steel grades, it is not to be incorporated into the system as a separate classification system, but rather as an adjustment rule. To this end, a reference value for the energy input for the ESR is defined to serve as the basis for evaluating the actual ESR systems in plants. The corresponding emissions for the ESR process are determined using this energy input. However, the emissions of the reference value are entered into the classification system with a value of 0. If the ESU plant does not exceed the reference value, it has no influence on its classification. If it does, the difference between the actual emissions and the reference value must be added. This avoids the creation of a new set of curves.

However, the downside of this approach is that it does not incentivise further decarbonisation of the process beyond the reference value. To address this, the option of mapping emission reductions using qualitative criteria, such as 100 % renewable electricity or the use of green hydrogen and synthesis gas, was considered. These criteria would then have to be met to achieve certain classification levels. However, as the use of such qualitative criteria would have represented a break with the previous LESS system, this option was rejected. The idea of bonus, which can be deducted proportionally from the reference value if the value falls below the reference value, was also not favoured.

As a result, if the actual energy consumption E_{ESR} is lower than the standard energy consumption $E_{ESR, St}$ ($E_{ESR} < E_{ESR, St}$), none of the above options for creating decarbonisation incentives should be implemented initially. However, the possibility of introducing such incentives at a later date should not be ruled out.

Deriving a reference value for the energy consumption (electricity) of the ESR is complex. Influencing factors are the composition and quantity of slag, the electrode diameter and the filling level, as well as the operating mode of the system within the respective company. This results in values that are highly specific to individual plants. Even the energy consumption values available in the literature are mostly empirical values for individual plants.

2.3. Implementation and Proposal

An important source for determining a reference value is the dissertation of Dr Jörg Korp⁵, who is still involved with the ESR as a consultant. In a direct exchange on a possible reference value, Dr Korp stated that 1,500 kWh/t steel would be a suitable average value for many plants.

This results in the following proposal for an adjustment rule for ESR:

- The default value $E_{ESR, st}$ for the energy consumption (electricity) of ESR is set at 1,500 kWh/t of steel. Assuming an emission factor of 0.485 kg CO₂/kWh for grey electricity (Scope 2: 0.4280 kg CO₂/kWh; Scope 3: 0.057 kg CO₂/kWh), a consumption of 1,500 kWh/t of electricity results in CO₂ emissions of 727.5 kg CO₂/t of steel. This emission level is decisive when applying the adjustment rule.
- The use of green electricity (emission factor Scope 2: 0; Scope 3: 0.0262 kg CO₂/kWh) results in CO₂ emissions of 39.3 kg CO₂/t steel for a consumption of 1,500 kWh. This means that emissions would be considerably lower than the reference value even with significantly higher electricity consumption.
- In addition, when applied to a real plant, the natural gas consumption for preheating and the associated emissions must be taken into account.

The reference value is subtracted from the actual emissions resulting from electricity and gas consumption. If the difference is positive, it is added to the classification system. If the difference is negative, however, the adjustment rule does not result in any changes to the classification system.

3. Ingot Casting

3.1. Rationale

Ingot casting is an important step in the further processing of steel, so including it in the rule book is a high priority for many steel companies. In particular, the inclusion of forged products depends on ingot casting being considered.

3.2. Methodology

An adjustment rule is defined for ingot casting. In ingot casting, excess material has a significant impact on the energy demand of subsequent processes. This poses a challenge, as the excess material depends on the block volume and the mould diameter. These parameters vary considerably, making it impractical to define the adjustment rule based solely on them. In addition, the production of different products results in varying block sizes and, consequently, different levels of excess material. Therefore, it is essential that the adjustment rule does not penalise higher excess material volumes, as these are determined by the product specifications.

It should also be noted that the excess material from ingot casting cannot be meaningfully separated from the excess material generated during forging or other hot forming processes.

The adjustment rule should follow the same methodology as hot rolling in the existing rulebook, but must take into account the actual excess material—defined by the resulting scrap—and deduct it accordingly.

⁵ Dr. Jörg Korp: „Einfluss ausgewählter Schlackenkomponenten auf den Energieverbrauch beim Elektroschlacke Umschmelzen (ESU)“, am Lehrstuhl für Metallurgie der Montanuniversität Leoben, November 2007.

3.3. Implementation and Proposal

Since excess material also increases the energy demand for heating during the forging process, it is considered in hot forming. This includes the case of hot rolling of ingot castings.

The calculation follows the same methodology as the existing rule for hot rolling: multiplication of the relevant inputs (energy, steel) by the ratio of the reference excess material—taken from the existing LESS rulebook—and the applicable excess material for the product being calculated.

The applicable excess material is always the actual excess material associated with the specific product.

The reference excess material varies depending on the relevant input type.

For steel input, the reference excess material is:

$$1.02 \times 1.05 = 1.071 \text{ (composed of the reference values for continuous casting and hot rolling, which may also be considered separately).}$$

For energy input during hot rolling of ingot castings, the reference excess material is:

$$1.05$$

The handling of energy inputs in connection with excess material in forging will be explained in the next chapter.

Example:

After ingot casting and forging, 130 t of liquid steel become 100 t of product.

$$130 \text{ t} * (1.02 * 1.05) / 1.3 = 107.1 \text{ t}$$

Only these 107.1 t of liquid steel and the associated emissions must be considered for the classification system.

4. Forging

4.1. Rationale

Forging is a prerequisite for manufacturing a wide range of products that are currently not covered in the LESS rulebook. Since the forging process occupies the same position in the process chain as hot rolling, it should be integrated into the existing system methodology in order to establish comparable system boundaries for forged and rolled products.

In this initial step, the extension shall apply exclusively to the variants of open-die forging and radial forging.

4.2. Methodology

The forging process is represented through an adjustment rule within the rulebook. This eliminates the need to define additional threshold values. To design the adjustment rule, a reference value for emissions from the forging process is determined based on the required energy inputs, enabling a consistent relative classification within the system—analogue to that of a rolling mill.

Relevant energy consumption in forging arises, on the one hand, from heating the steel ingot, which is typically carried out using gas-fired furnaces. On the other hand, electricity consumption results from the subsequent forming of the steel ingot.

The number of heating cycles and forming steps varies depending on the facility and the product being manufactured, which presents a challenge in defining an appropriate reference value.

To determine a suitable reference value for gas and electricity consumption, both publicly available sources and databases were consulted. In addition, a competition-law-compliant data inquiry was conducted among forging companies, with plausibility checks performed by FutureCamp Climate as an independent third party.

4.3. Implementation and Proposal

To integrate forging into the existing systems, the actual energy inputs (kWh/t) are compared to the reference energy inputs for forging. This results in an adjustment factor, which is then used to multiply the energy inputs of the reference rolling mill. This approach ensures that the process itself is not penalized for higher emissions.

Energy inputs consist of fuel consumption for heating and electricity consumption for forming. To calculate the emissions included in the system, the resulting energy inputs are multiplied by the emission factors of the actual energy carriers used. If a forged piece is heated inductively or by other electrical means, the corresponding electricity consumption is attributed to heating rather than forming.

If the actual energy input of a forging facility is below the reference energy input, the resulting adjustment factor is <1. This leads to the facility being classified in the same way as a rolling mill that operates below its reference energy input to the same extent.

As a result, a forging facility with 20% lower emissions than the reference value is classified in the same way as a rolling mill with 20% lower emissions than the reference rolling mill.

The excess material is fully excluded from the calculation—both in terms of steel input (as described in the chapter on ingot casting) and energy input for heating and forming. Accordingly, the relevant quantity of crude steel for determining the emissions of one ton of forged product under the LESS framework is always 1.05 t of crude steel. The relevant quantity of liquid steel (prior to ingot casting) for determining the emissions of one ton of forged product under LESS is 1.071 t of liquid steel.

No reference value for excess material in forging is required to exclude energy inputs caused by excess material. Since the reference energy inputs in the forging process already relate to the input quantity in forging rather than the final product, the actual excess material is inherently accounted for in this step.

The rules for handling energy inputs apply regardless of the energy sources used. In particular, this includes by-product gases and other fuels in addition to natural gas.

For all other emission-relevant inputs within the forging process—excluding energy inputs and steel input—the existing system rules apply, including the cut-off criterion. Since these inputs are significantly less relevant compared to energy consumption, they are to be considered in their actual amount.

Based on literature research and the industry survey, reference values were established for gas consumption during heating and electricity consumption during forming. The survey also revealed the necessity of distinguishing between “small” and “large” forged pieces, as many forging products undergo multiple reheating steps to ensure formability.

Large forged pieces require significantly higher energy input, especially for (re)heating, due to material-specific conditions. The equipment used for this purpose also exhibits higher heat losses. Therefore, a single set of reference values would either favor small forged pieces or disadvantage larger ones.

Accordingly, it is reasonable to differentiate the reference values for heating steel ingots based on the mass of the input material. As a result, one set of reference values was defined for forged pieces with input formats below 70 tonnes, and another set for forged pieces with input formats equal to or greater than 70 tonnes. The input format refers to the pre-material introduced into the forging process at its starting point.

Reference values for energy consumption – heating

The baseline value for the first heating cycle is 1,200 kWh/t for all reference values, based on a study by the German Environment Agency (UBA)⁶. For more than one heating cycle, a linear increase is assumed—based on a percentage of the baseline value for each additional cycle.

This approach reflects the fact that the first heating requires overcoming a large temperature difference, whereas in subsequent cycles, the workpiece already retains a significantly higher temperature than its initial state. As a result, the temperature difference to be overcome is smaller, leading to lower energy demand.

For larger (more massive) input formats of 70 tonnes or more, the additional energy demand per subsequent heating cycle is set at 50% of the baseline value. For smaller formats below 70 tonnes, the value is set at 40% of the baseline.

The resulting reference values are shown below.

Reference values for forge heating for input formats below 70 tonnes

Assumption: each additional heating cycle requires 40% of the baseline energy input.

Literature value – 1 st heat	Sum of 1 st - 2 nd heat	Sum of 1 st - 3 rd heat	Sum of 1 st - 4 th heat	Sum of 1 st - 5 th heat	Sum of 1 st - 6 th heat	Sum of 1 st - 7 th heat
1,200 kWh/t	1,680 kWh/t	2,160 kWh/t	2,640 kWh/t	3,120 kWh/t	3,600 kWh/t	4,080 kWh/t

Reference values for forge heating for input formats of 70 tonnes or above

Assumption: 50% of the initial value in additional energy input for each additional heat.

Literature value – 1 st heat	Sum of 1 st - 2 nd heat	Sum of 1 st - 3 rd heat	Sum of 1 st - 4 th heat	Sum of 1 st - 5 th heat	Sum of 1 st - 6 th heat	Sum of 1 st - 7 th heat
1,200 kWh/t	1,800 kWh/t	2,400 kWh/t	3,000 kWh/t	3,600 kWh/t	4,200 kWh/t	4,800 kWh/t

Reference value for a hot rolling mill heating for comparison

1.5 GJ/t (416.67 kWh/t)

Reference values electricity consumption in forging for forming

The same reference values apply for all formats for the electricity used for forming. The starting value for forming after the first heat is 100 kWh/t, as derived from the UBA study *CO₂-Neutral Process Heat Generation*⁷. For each additional forming step following further heating cycles, a linear increase of 100 kWh per heating cycle is assumed.

⁶ CO₂-neutrale Prozesswärmeerzeugung - Umbau des industriellen Anlagenparks im Rahmen der Energiewende: Ermittlung des aktuellen SdT und des weiteren Handlungsbedarfs zum Einsatz strombasierter Prozesswärmeanlagen, UBA, 2023, <http://www.umweltbundesamt.de/publikationen>

⁷ <https://www.iob.rwth-aachen.de/en/projects/uba-study/>

Electricity Consumption for Forming

1st heat	2nd heat	3rd heat	4th heat	5th heat	6th heat
100 kWh/t	200 kWh/t	300 kWh/t	400 kWh/t	500 kWh/t	600 kWh/t

Reference value for electricity consumption during forming in a hot rolling mill for comparison

100 kWh/t

Application:

The operator determines the actual electricity and fuel consumption per tonne of input material for each product or classification group. This value is compared with the applicable reference value for forging. The resulting ratio yields a factor that is used to multiply the fuel or electricity consumption of the reference rolling mill.

Reference fuel input in the forge: $Ref_Input_{BS,S}$

Reference fuel input in the rolling mill: $Ref_Input_{BS,WW}$

Actual steel input in the forge: $Input_{Stl,S}$

Actual fuel input per tonne of input material: $Input_{BS,S}$

Actual total fuel input in the forging process: $Input_{BGS,S}$

Adjustment factor from forge to rolling mill: $AF_{S,WW}$

Equivalent value for fuel input per tonne of product: $\ddot{A}qv_Input_{BS,S}$

Determination of actual fuel consumption per tonne of input material in the forging process:

$$Input_{BS,S} = \frac{Input_{BGS,S}}{Input_{Stl,S}}$$

Comparison of the fuel consumption per tonne with the reference value for fuel input for forging to determine the adjustment factor from the forge to the rolling mill:

$$AF_{S,WW} = \frac{Input_{BS,S}}{Ref_Input_{BS,S}}$$

Multiplication of the adjustment factor with the reference fuel input of the rolling mill to determine the equivalent value:

$$\ddot{A}qv_Input_{BS,S} = AF_{S,WW} \times Ref_Input_{BS,WW}$$

The calculation can also be carried out in the same way for larger quantities of input material by multiplying the reference values by the same quantity. The fuel input for determining the equivalent value is multiplied by the actual emission factors of the fuels used to calculate the resulting emissions.

The calculation can also be applied analogously to larger quantities of input material by multiplying the reference values by the same amount. The fuel input used to determine the equivalent value is then multiplied by the actual emission factors of the fuels used to calculate the resulting emissions.

The calculation logic applies analogously to electricity consumption.

Example 1

Forging process with 3 heating cycles (input format < 70t)

Reference forge: Fuel input for heating (3 heats): 2,160 kWh/t of input material

Reference rolling mill: Fuel input for heating: 416.7 kWh/t (1.5 GJ/t) of input material.

A forge has a fuel input of 2,700 kWh/t input material. In Case A, 2 tonnes of input material are required for 1 tonne of product, in Case B only 1.5 tonnes of input material.

Case A: Fuel input in the forging process = 2,700 kWh/t * 2 t = 5,400 kWh (this corresponds to the recorded fuel input)

Adjustment for excess input is made by multiplying the fuel quantity by the ratio of product quantity to input material:

$$5,400 \text{ kWh} * (\frac{1}{2}) = 2,700 \text{ kWh}$$

-> This yields the fuel input per tonne of input material.

Comparison with the reference value (2,700 kWh/2,160 kWh) results in a 25% higher fuel consumption than the reference forge. The fuel consumption of the reference forge is multiplied by a factor of 1.25 in Case A for classification in the system.

Case B: Fuel input in the forging process = 2,700 kWh/t * 1.5 t = 4050 kWh (this corresponds to the recorded fuel input).

Adjustment for excess input is made by multiplying the fuel quantity by the ratio of product quantity to input material:

$$4050 \text{ kWh} * (1/1.5) = 2,700 \text{ kWh}$$

-> Again this yields the fuel input per tonne of input material.

Comparison with the reference value (2,700 kWh vs. 2,160 kWh) results in a 25% higher fuel consumption than the reference forge. The fuel consumption of the reference forge is multiplied by the adjustment factor 1.25 in Case B in the calculation for classification in the system.

Conclusion: The different excess input in Cases A and B does not lead to different results in the system.

Example 2

A forge has a fuel input of 1,620 kWh/t of input material. 2 t of input material are required for 1 t of product.

Fuel input in the forging process = 1,620 kWh/t * 2.0 t = 3,240 kWh (this corresponds to the recorded fuel input).

Adjustment for excess input is made by multiplying the fuel quantity by the ratio of product quantity to input material:

$$3,240 \text{ kWh} * (1/2) = 1,620 \text{ kWh}$$

-> This yields the fuel input per tonne of input material.

Comparison with the reference value (1,620 kWh vs. 2,160 kWh) results in a 25% lower fuel consumption than the reference forge. The fuel consumption of the reference forge is multiplied by the adjustment factor of 0.75 for example 2 for classification in the system.

In comparison to example 1: 0.75 corresponds exactly to 60% of 1.25 and thus precisely reflects the ratio of the different fuel inputs (1,620 kWh vs. 2,700 kWh).

Conclusion: Differences in fuel efficiency are accurately reflected in the system results.

5. Tube Rolling

5.1. Rationale

The inclusion of tube rolling in the LESS regulations enables the system to be extended to another important part of the steel value chain.

5.2. Methodology

Tube rolling is to be integrated into the system using an adjustment rule. The initial objective was to establish a reference value for the tube rolling emissions based on the required energy input. The tube rolling process should be classified within the same relative framework as conventional hot rolling in the existing system. Under current methodologies, emissions would be benchmarked against those of a reference hot rolling mill, with the actual emissions of a given facility divided by this reference factor to determine its classification

This prevents the process itself from being penalised for higher emissions. Consequently, a tube rolling mill with 20 % lower emissions than the reference value would be categorised in the same way as a rolling mill with 20 % lower emissions than the reference rolling mill.

However, as it was not possible to request data from the participating companies on this matter, and publicly available sources did not provide sufficient data, a transitional solution has been adopted for the time being, whereby only changes in energy sources are decisive for categorisation. It is recommended LESS aisbl to carry out a data enquiry with an extended group of participants to be able to define a reference value for tube rollers.

5.3. Implementation and Proposal

To categorise rolled pipes in the classification system in a meaningful way, a simplified approach has been chosen. This essentially involves considering the energy sources used in the tube rolling mill in order to map the most important transformation steps. The energy inputs from the hot rolling reference process are used in the calculation. These are

Natural gas for heating: 1.5 GJ

Electricity: 100 kWh

A reference value of 1.05 is also used for the excess material in the tube rolling mill, analogous to hot rolling. This means that in the first step, an input quantity of 1.05 tonnes of crude steel are taken into account for each tonne of rolled pipe, regardless of the actual input quantity of crude steel.

However, the emission factors of the energy sourced used in the respective tube rolling mill must be taken into account at their actual values. The reference values mentioned above are to be multiplied by these emission factors to calculate the resulting emissions. Additional input materials used in the tube

rolling mill (e.g. oxygen) must be accounted for based on their actual consumption, unless they fall under the established cut-off criterion.

Classification is carried out according to the respective steel grade into the appropriate system: QST, BST, or stainless steel.

If different classification groups are formed within a tube rolling mill based on the use of energy sources with varying emission factors (e.g. biomethane and natural gas), only the specific energy carriers relevant to each group may be used for calculation. It must be ensured and documented that the declared energy carrier was actually used in sufficient quantity to produce the stated product volumes within that classification group. This verification explicitly refers not to the reference values mentioned above, but to the actual energy consumption in the respective plant.

Example:

A tube rolling mill uses quality steel with a 100% scrap share and CO₂ emissions of 550 kg CO₂/t. It uses a mixture of 50% biomethane with scope 3 emissions of 17.50 kg CO₂/GJ⁸ and 50% natural gas with total emissions of 67.3 kg CO₂/GJ, resulting in total emissions of 42.4 kg CO₂/GJ. Mains electricity with an emission factor of 0.485 kg CO₂/kWh is also used.

The following values result for the reference rolling mill:

With an excess input factor of 1.05, 1.05 tonnes of steel input material are per tonne of final product

The gas demand is: 1.5 GJ/t of rolled product

The electricity demand is 100 kWh/t of rolled product.

In the example tube rolling mill, however, 2.0 GJ/t of a gas mixture and 120 kWh/t of electricity are used per tonne of product. These actual values are higher than the reference values of the hot rolling mill. For classification of the tube rolling mill within the system, only the reference values and the actual emission factors are used in the calculation.

The total emissions for classification per tonne of final product from the tube rolling mill are as follows:

$$550 \text{ kg CO}_2 \cdot 1.05 + 1.5 \text{ GJ} \cdot 42.4 \text{ kg CO}_2 / \text{GJ} + 100 \text{ kWh} \cdot 0.485 \text{ kg CO}_2 / \text{kWh} = 689,6 \text{ kg CO}_2$$

This would result in classification D in the quality steel classification system.

Assuming that the company switches to 100% biomethane and green electricity (Scope 3 emissions: 0.0262 kg CO₂/kWh) with unchanged excess quantities and energy requirements, the following results are obtained:

$$550 \text{ kg CO}_2 \cdot 1.05 + 1.5 \text{ GJ} \cdot 17.5 \text{ kg/GJ} + 100 \text{ kWh} \cdot 0.0262 \text{ kg/kWh} = 606.37 \text{ kg CO}_2$$

This would result in classification C in the quality steel classification system.

⁸ https://www.umweltbundesamt.de/sites/default/files/medien/1410/publikationen/2019-11-07_cc-37-2019_emissionsbilanz-erneuerbarer-energien_2018.pdf



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Information status
09/2025