

TKDN SELF-ASSESSMENT OF REVERSE-ENGINEERED COAL PIPE FABRICATION AT PLN PUSHARLIS: A CASE STUDY

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Abstract

Dependence on imported spare parts in coal-fired power plants increases procurement cost and delivery time, while critical components such as the Coal Pipe are exposed to abrasive wear and elevated operating temperatures. This study evaluates the Domestic Component Level (Tingkat Komponen Dalam Negeri/TKDN) of an SS400 Coal Pipe fabricated by PLN Pusharlis through reverse engineering. A case-study self-assessment was conducted by integrating engineering documents, manufacturing flow, shop drawings, bill of materials, procurement realization, labor, and factory-overhead data with the cost-classification approach required by Indonesian Ministry of Industry Regulation No. 16/M-IND/PER/2/2011. The fabrication approach references ASTM G65 for abrasion-related material considerations and ASME Section IX for welding qualification. The detailed production-cost structure totals IDR 39,571,487.44, consisting of IDR 24,551,412.26 domestic components and IDR 15,020,075.18 foreign components, resulting in a TKDN value of 62.04%. The foreign share is concentrated mainly in primary raw materials, whereas direct labor, indirect labor, and most overhead are domestically sourced. The case demonstrates that reverse engineering can support import substitution while providing an auditable basis for domestic-content accountability.

Keywords: Coal Pipe; Import Substitution; Reverse Engineering; TKDN

INTRODUCTION

PT PLN (Persero) operates within an electricity system in which the continuity and reliability of generating assets are closely related to the availability of critical spare parts. Coal-fired power plants continue to require a wide range of components that are exposed to demanding operating conditions. When those components depend on imports, procurement lead time and cost can increase, creating operational risk for maintenance activities and plant availability. The Indonesian government addresses this challenge through domestic-product policies and the Domestic Component Level (Tingkat Komponen Dalam Negeri/TKDN), which provides a quantitative basis for measuring the domestic share of a manufactured product (Kementerian Perindustrian RI, 2011).

Within the PLN ecosystem, PLN Pusharlis performs an engineering and manufacturing role intended to reduce dependence on imported power-plant parts. One approach is reverse engineering, in which an existing component is examined, dimensionally reconstructed, technically evaluated, and then reproduced using available manufacturing resources. This approach is particularly relevant when original equipment manufacturer (OEM) parts are costly, have long delivery times, or are associated with restricted technical documentation. The source case identifies reverse engineering as a means of linking technical reconstruction with internal workshops and capable domestic partner workshops, including small and medium industrial actors.

The Coal Pipe is one of the components selected for this strategy. Its function is to convey pulverized coal toward the boiler system, and its internal surface is continuously exposed to high-velocity abrasive particles. Excessive wear in coal-handling and coal-mill duct systems can cause rapid loss of wall thickness and shorten component life when material selection and fabrication quality are inadequate (Bawa et al., 2022). The case therefore places emphasis on dimensional accuracy, material specification, abrasion-related considerations, qualified welding procedures, and quality control. The engineering drawing used by PLN Pusharlis specifies SS400 structural steel for the reconstructed component, while the fabrication process references ASTM G65 and ASME Section IX as technical bases for material-wear consideration and welding qualification.

Technical success alone, however, does not fully demonstrate the strategic value of local manufacturing. A reverse-engineered product must also show how much of its production value is actually generated domestically.

This requires a transparent separation between Komponen Dalam Negeri (KDN, domestic components) and Komponen Luar Negeri (KLN, foreign components) across direct materials, labor, machinery-related cost, and factory overhead. Such classification makes it possible to evaluate whether local manufacturing is merely an assembly activity or whether it meaningfully increases domestic value creation. Previous work cited in the source manuscript discusses reverse engineering for power-plant spare parts (Wang & Chang, 2020), wear-related problems in coal-mill components (Bawa et al., 2022), workplace risk control in welding and heavy fabrication (Lestari & Wijaya, 2023), and design innovation associated with Coal Pipe systems (Nugroho et al., 2025). Nevertheless, the source study identifies a practical gap: limited documentation that integrates the reverse-engineering workflow with a real TKDN self-assessment based on actual fabrication costs. This study therefore aims to formulate the TKDN achievement of a reverse-engineered SS400 Coal Pipe fabricated by PLN Pusharlis and to explain which cost components most strongly increase or reduce domestic content. The expected contribution is a traceable case model for evaluating technical localization and domestic-value creation in power-plant component manufacturing.

LITERATURE REVIEW

Reverse Engineering for Power-Plant Spare Parts

Reverse engineering begins with a physical product rather than an abstract design concept. The existing component is decomposed into measurable features, functional relationships, material requirements, and manufacturing constraints, after which the information is reconstructed into an engineering model or drawing. In the source manuscript, this process is described as a sequence of deconstruction and reconstruction rather than simple imitation. The objective is to understand the technical reasoning embedded in the original product so that a replacement can be produced with controlled dimensions, material characteristics, and fabrication procedures. Wang and Chang (2020) are cited in the source as a reference for dimensional deconstruction and quality control in power-plant spare-parts manufacturing.

For the Coal Pipe case, reverse engineering translates field and component information into shop drawings, process planning, material selection, machine requirements, quality-control points, and a bill of materials. The PLN training module on design and product development is also used in the source as an internal engineering reference (PT PLN [Persero] PUSDIKLAT, 2026). This linkage is important because TKDN calculation requires not only a final product but also an identifiable production structure. The engineering design therefore becomes the technical basis for determining which materials, labor activities, and workshop resources enter the domestic-content calculation.

TKDN as a Domestic-Content Accountability Metric

TKDN is used in the source study as a quantitative measure of the proportion of production cost that originates domestically. Referring to Ministry of Industry Regulation No. 16/M-IND/PER/2/2011, the calculation classifies production costs into domestic and foreign components and then compares domestic cost with the total production cost (Kementerian Perindustrian RI, 2011). For a manufactured product, the relevant cost structure includes direct materials, direct labor, and factory overhead. The assessment therefore depends on traceable procurement records, labor origin, equipment ownership or rental, and other indirect production costs.

The analytical value of TKDN in a reverse-engineering project is that it separates physical localization from economic localization. A component may be fabricated in Indonesia while still containing a substantial foreign share if the major raw material, machinery, consumables, or other inputs are imported. Conversely, locally supplied labor, fabrication services, indirect labor, and domestic overhead can materially increase the domestic share. The resulting percentage becomes an auditable indicator that can be linked to import-substitution policy and industrial capability development.

Fabrication Standards, Wear Considerations, and K3L

Coal Pipe fabrication requires attention to both service conditions and manufacturing integrity. The source manuscript associates material selection with ASTM G65, a standard test method for measuring abrasion using the dry sand/rubber wheel apparatus (ASTM International, 2021). The standard is used as a reference point for abrasion-related material considerations because the component transports abrasive coal particles. Welding activities are associated with ASME Boiler and Pressure Vessel Code Section IX, which addresses welding and brazing qualifications. These references provide a technical framework for selecting and controlling fabrication processes, although the source case focuses on TKDN calculation rather than presenting a separate laboratory-validation program.

The source also integrates occupational safety and professional engineering practice into the manufacturing context. Job Safety Analysis (JSA), personal protective equipment, ventilation for welding activities, and management of fabrication waste are identified as elements of the workshop process. Lestari and Wijaya (2023) are cited in relation to HIRARC/JSA-based risk analysis in welding and heavy-manufacturing workshops. In addition, the manuscript relates the work to the professional-engineer competency framework of Persatuan Insinyur Indonesia, emphasizing that technical decisions should prioritize safety, health, public welfare, and product quality. These elements are relevant to TKDN because locally sourced safety equipment and indirect production resources may also form part of factory overhead when supported by valid cost evidence.

METHOD

This research uses a descriptive case-study approach combined with a quantitative TKDN self-assessment. The unit of analysis is one SS400 Coal Pipe product fabricated by PT PLN Pusharlis UP2W II. The study integrates two evidence streams: (1) engineering evidence describing how the component is reconstructed and fabricated, and (2) cost evidence showing the domestic or foreign origin of each production input. The analysis is based on the engineering and realization documents listed in the source manuscript, including the manufacturing flow, shop drawing, bill of materials, procurement and service realization, workshop cost data, Job Safety Analysis, the 2025 final fabrication report, and the December 2025 performance report.

The reverse-engineering stage consists of dimensional deconstruction of the existing component, reconstruction of the geometry into a shop drawing, identification of material specifications, planning of fabrication steps, and determination of the machines and labor required. For the Coal Pipe segment, the process includes SS400 plate preparation, gas cutting, plate rolling, hardfacing welding, grinding, and quality control. The flange route includes material preparation, gas cutting, laser-hole cutting, grinding, and quality control. Both routes converge in part setting, full assembly, final quality control, packaging, and delivery.

Material requirements are quantified through a bill of materials. The source table calculates the mass of each segment using geometry and a steel density of 7,850 kg/m³, then adds a 5% waste allowance. The bill of materials is used to connect the engineering drawing to the actual quantity of material required for one Coal Pipe. Procurement realization and associated services are then classified as KDN or KLN according to their origin.

For the TKDN calculation, production cost is grouped into direct materials, direct labor, and factory overhead. Each item is assigned a domestic-cost value and, where applicable, a foreign-cost value. The basic relationship used in the study is:

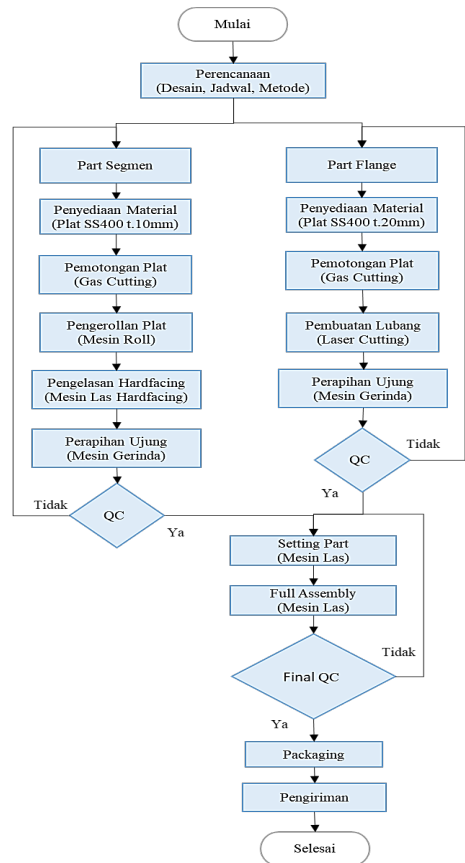
$$\text{TKDN (\%)} = (\text{Domestic Component Cost} / \text{Total Production Cost}) \times 100$$

The final percentage is interpreted together with the detailed cost composition to identify the principal sources of domestic value and the cost categories that remain dependent on foreign inputs. The method does not replace formal third-party certification; it is a producer self-assessment intended to provide a structured and auditable calculation basis from the available project evidence.

RESULTS AND DISCUSSION

Reverse-Engineering and Manufacturing Flow

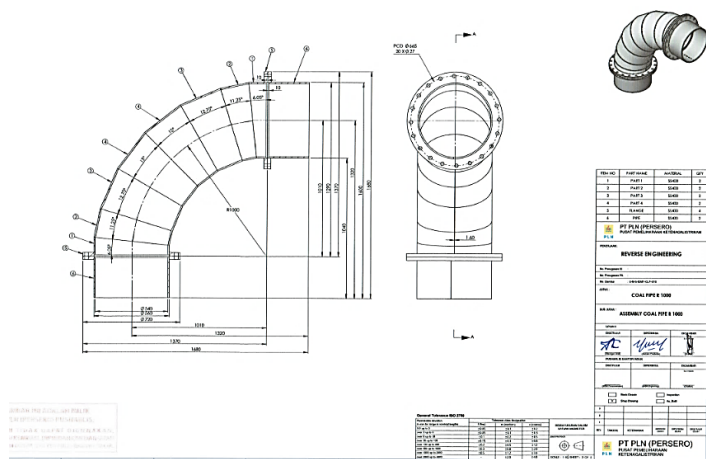
The reverse-engineering output provides the sequence required to transform the reconstructed design into a manufacturable Coal Pipe. Figure 1 shows two parallel production routes. The segment route starts with 10 mm SS400 plate and proceeds through gas cutting, rolling, hardfacing welding, edge grinding, and quality control. The flange route starts with 20 mm SS400 plate and proceeds through gas cutting, laser-hole cutting, edge grinding, and quality control. After each route passes inspection, the parts are set and assembled by welding, followed by final quality control, packaging, and shipment. The flow demonstrates that the product is not merely assembled from imported finished parts; a substantial share of value is created through local fabrication activities.



Source: PLN PUSHARLIS Engineering Data, Flowchart (2025)

Figure 1: Coal Pipe manufacturing flow process

Figure 2 translates the reconstructed geometry into a fabrication drawing. The drawing identifies the curved segmented body, flange arrangement, critical dimensions, and the material list for the assembly. In the context of TKDN, this shop drawing is important because it defines the material thicknesses, part quantities, and production operations that later appear in the bill of materials and cost structure. The source manuscript notes that the Coal Pipe design uses SS400 steel and that the fabrication process is planned with reference to abrasion-related and welding-qualification standards.



Source: PLN PUSHARLIS Engineering Data, Shopdrawing (2025)

Figure 2: Reverse-engineered Coal Pipe shop drawing

Bill of Materials and Material Requirement

The bill of materials converts the shop drawing into measurable production input. Table 1 summarizes the principal SS400 components reported in the source manuscript. The four pipe segments use 10 mm plate, whereas the flange uses 20 mm plate. A 5% waste allowance is included in the material estimate. This step is central to the self-

assessment because it establishes a traceable physical basis for direct-material cost rather than relying only on aggregate purchasing figures.

Table 1. Summary of the Coal Pipe bill of materials

Component	Qty	Material	Principal dimension (mm)	Plate t. (mm)	Mass + 5% waste (kg)
Segment 1	2	SS400	L 1850.66 × W 298.41	10	91.039
Segment 2	2	SS400	L 1850.66 × W 367.53	10	112.127
Segment 3	2	SS400	L 1850.66 × W 359.29	10	109.613
Segment 4	1	SS400	L 1850.66 × W 346.70	10	52.886
Flange	4	SS400	Ø 750	20	110.980
Bolts, nuts, spring/flat washers	40 pcs	Bolt class 8.8	90 × 24	—	Not reported

Source: Processed from the source manuscript Bill of Material (2026)

The estimated mass figures also illustrate why raw material is the dominant cost category. The segmented geometry requires several large SS400 plates and flanges before hardfacing, assembly, and finishing are performed. In the source calculation, the main direct-material category therefore accounts for IDR 26,788,774.40 of the production cost. This cost concentration becomes the main constraint on the overall TKDN percentage when a large portion of the primary material is classified as foreign content.

Fabrication Realization, Quality Control, and K3L

The workshop realization shown in Figure 3 illustrates the local fabrication stage after parts have been formed and welded. Grinding is used to finish the welded edges and prepare the component for subsequent quality control and assembly. The source manuscript states that the fabrication activities are accompanied by Job Safety Analysis and the use of appropriate personal protective equipment. This is consistent with the principle that domestic manufacturing capability must be evaluated not only by output quantity but also by safe, controlled, and repeatable work practices.



Source: PLN PUSHARLIS Engineering Data, Final Report (2025)

Figure 3: Grinding and finishing of welded Coal Pipe edges

K3L-related resources also have a cost implication. The source manuscript notes that locally sourced personal protective equipment and other indirect production requirements can be classified within factory overhead when supported by project records. This creates an important link between safe engineering practice and domestic value

creation: safety expenditure is not treated as separate from the production system but as part of the real resources required to manufacture the component.

TKDN Cost Structure and Domestic-Content Achievement

Table 2 presents the detailed producer self-assessment reported in the source manuscript. The calculation results in domestic component cost of IDR 24,551,412.26 and foreign component cost of IDR 15,020,075.18, producing a total cost of IDR 39,571,487.44. Dividing domestic cost by total production cost yields a TKDN value of 62.04%. The result shows that more than half of the production value is generated domestically, even though the primary raw-material category still contains a significant foreign share.

Table 2. TKDN self-assessment for one SS400 Coal Pipe

Cost component	KDN (IDR)	KLN (IDR)	Total (IDR)	TKDN contribution
Primary direct material	11,785,645.98	15,003,128.42	26,788,774.40	29.78%
Other direct material-related cost	6,586,765.18	—	6,586,765.18	16.65%
Direct labor	907,242.26	—	907,242.26	2.29%
Other direct-labor related cost	88,002.50	—	88,002.50	0.22%
Indirect labor	2,647,633.60	—	2,647,633.60	6.69%
Owened machinery	525,545.90	2,488.43	528,034.33	1.33%
Rented machinery	—	—	—	0.00%
Other factory overhead	2,010,576.85	14,458.33	2,025,035.18	5.08%
TOTAL	24,551,412.26	15,020,075.18	39,571,487.44	62.04%

Source: Processed from the source manuscript TKDN calculation (2026)

The primary direct-material category is the largest cost block and the main source of foreign content. Its total value is IDR 26,788,774.40, of which IDR 15,003,128.42 is classified as KLN and IDR 11,785,645.98 as KDN. The domestic contribution from this category is 29.78 percentage points. This pattern indicates that the limiting factor is not the ability to fabricate the component locally, but the origin of upstream structural-steel and related primary inputs. The source manuscript explicitly identifies the availability of domestic upstream steel as a constraint.

In contrast, the other material-related category is fully domestic at IDR 6,586,765.18 and contributes 16.65 percentage points. Direct labor and associated labor cost are also fully domestic, totaling approximately IDR 995,244.76 and contributing 2.51 percentage points. Indirect labor contributes an additional 6.69 percentage points. These values confirm that workshop skills and human resources are a strong localization asset in the case. Factory overhead provides another important contribution. Owened machinery includes only a small KLN portion of IDR 2,488.43, while other factory overhead contains KLN of IDR 14,458.33. The remaining overhead is domestic. The combined pattern supports the interpretation that the manufacturing ecosystem, labor, and most workshop-support activities are already localized to a much greater extent than the primary raw material.

From an engineering-management perspective, the 62.04% result has two implications. First, reverse engineering has converted an import-dependent component into a locally manufacturable product with a majority domestic cost share. Second, the calculation reveals the next localization priority: increasing the domestic origin of primary steel and selected imported equipment-related inputs. Thus, the TKDN self-assessment functions not only as a compliance calculation but also as a diagnostic tool for identifying where industrial-development efforts can have the greatest effect. The case also demonstrates the relationship between technical documentation and cost accountability. The manufacturing flow, shop drawing, bill of materials, work realization, and cost classification form a continuous audit trail. Without the reverse-engineering documentation, the cost table would lack a strong

technical basis; without the TKDN calculation, the engineering achievement would not show the extent of domestic value creation. Integrating both perspectives therefore produces a more complete evaluation of import-substitution performance.

CONCLUSION

The case study shows that an SS400 Coal Pipe fabricated by PLN Pusharlis through reverse engineering achieves a producer self-assessed TKDN of 62.04%. Based on the detailed cost table, domestic components amount to IDR 24,551,412.26, foreign components to IDR 15,020,075.18, and total production cost to IDR 39,571,487.44. The largest foreign-content burden is concentrated in primary direct material, while direct labor, indirect labor, other material-related costs, and most factory overhead are domestically sourced.

Reverse engineering contributes to the result by establishing the technical definition of the product through dimensional reconstruction, shop drawing, material specification, process planning, bill of materials, fabrication, and quality-control stages. The TKDN assessment then translates these engineering decisions into an economic measure of domestic value. Together, the two approaches provide a practical framework for evaluating import substitution in power-plant spare-parts manufacturing.

For further localization, the cost structure indicates that the greatest potential lies in increasing the domestic origin of upstream steel and reducing the remaining foreign share in machinery-related and indirect inputs. The source case also emphasizes that these efforts should remain aligned with welding qualification, abrasion-related material requirements, K3L controls, and professional engineering responsibilities. The reported value is a self-assessment and should be distinguished from formal external TKDN certification.

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