Environmental Product Declaration

In accordance with ISO 14025 and EN 50693:2019 for:

Distribution Transformer – 100kVA (6923-211460A)

from

Indústria de Transformadores Itaipu Ltda.

Declaration number	EPDItaipu01
Production site:	Itápolis, São Paulo - Brazil
Programme:	EPDItaly®, www.epditaly.it
Programme operator:	EPDItaly
EPD registration number:	EPDITALY0294
Issue date:	2022-05-31
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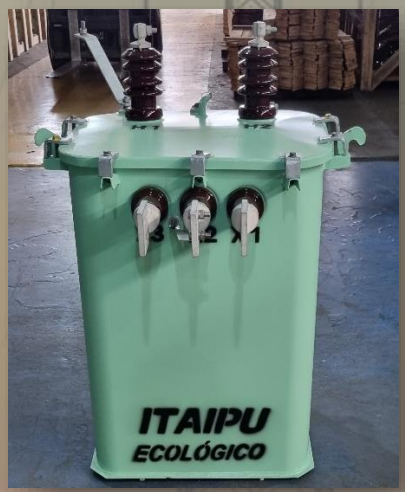

General information

Programme information

Programme:	EPDItaly®
Address:	EPDItaly Via Gaetano De Castillia, 10 20124 – Milano Italy
Website:	www.epditaly.it
E-mail:	info@epditaly.it

Scope of application:	*Distribution Transformer – 100kVA (code 6923-211460A): one-phase distribution transformer in vegetable cooled oil, with low level of loss and noise and 100kVA of nominal power. Cradle to grave with 35 years of reference service life (RSL).*
Functional unit:	*A single piece of transformer operating for 35 years*
CPC code:	*46121 - Electrical transformers*
Geography:	*World (raw materials), Brazil (production, use and end-of-life)*
LCA report	*[Itaipu-LCA] 100kVA transformer_final report_v2.0 (2022)*
Product category rules (PCR):	*Core PCR EPDItaly007:20 Electronic and Electrical Products and Systems, revision 2 (2020-10-21)* *Sub PCR EPDItaly018:21 Electronic and Electrical Products and Systems – Power Transformers, version 3.5 (2021-12-13)*
Other references:	*Regulations of the EPDItaly Programme rev 5.0, 2020-01-07* EN 50693 is the framework reference for the Product Category Rules (PCR)
Core PCR review was conducted by:	*ICMQ S.p.A. – Certificazioni e controlli per le costruzioni* *Moderator: Eng. Vito D'Incognito, Take Care International*
Sub PCR review was conducted by	*ENEL S.p.A.; Life Cycle Engineering* *Moderator: Massimo De Pieri, Life Cycle Engineering*

Independent third-party verification of the declaration and data, according to ISO 14025:2006:
☐ internal ☒ external

Third party verification carried out by:
ICMQ spa - Via Gaetano De Castillia, 10 - 20124 – Milano/Italy

Procedure for follow-up of data during EPD validity involves third party verifier:
☒ Yes ☐ No

The EPD owner has the sole ownership, liability, and responsibility for the EPD.
EPDs relating to the same category of products but belonging to different programmes may not be comparable. EPDs of electronic and electrical products may not be comparable if they do not comply with EN 50693. For further information about comparability, see EN 50693 and ISO 14025.

Company information

Owner of the EPD:	Indústria de Transformadores Itaipu Ltda.
Address:	Avenida Sergio Abdul Nour, 2106, Distrito Industrial II
Location of production site(s):	Itápolis, State of São Paulo, Brazil
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About the organization

Founded in 1975, Industria de Transformadores Itaipu Ltda is a national reference company in the manufacture of distribution and power transformers, serving with excellence the private markets and electricity concessionaires in Brazil and Latin America. Itaipu portfolio includes single-phase, three-phase, ecological, power and special transformers, designed to meet the specifications of each customer, including commerce, industries, electricity concessionaires, cooperatives, installers and contractors.

Itaipu mission is to offer solutions in generation, transmission and distribution of electric energy guaranteeing the satisfaction of its customers, employees, partners and shareholders.

TECHNOLOGY THAT TRANSFORMS

Sustainability

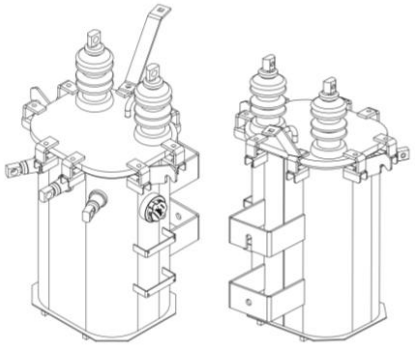
Itaipu has the sustainability as one of the core values and includes continuous improvement, compliance with national laws, employee consciousness about company environmental policy, health and insurance working environment passing through lean manufacturing principles with waste generation reduction and controlled raw material consumption. Itaipu Transformers Industry and all its actions are obligatory to respect human rights, combating discrimination in all its forms. The company holds ISO 9001, ISO 14001 and ISO 45001 certifications.

Owned certifications

Product information

Product name:	Distribution Transformer – 100 kVA
Product description:	The 6923-211460A Distribution Transformer is an electrical device that transfer energy from one circuit to another by magnetic coupling without requiring relative motion between its parts and comprises two coupled windings and a magnetic core to concentrate magnetic flux made os silicon-steel. It is a one-phase transformer in vegetable cooled oil, with nominal power of 100kVA and final project mass (without packaging) of 602.70 kg. The packaging consist of wooden bars.
Average dimensions:	890 mm length x 1420 mm height x 860 mm width
Expedition weight:	672.70
Product weight:	602.70 kg
Packaging weight:	70.00 kg
Type:	Distribution, oil-immersed
Number of phases:	1P
Voltage class:	low
Nominal primary voltage	15.0 kV
Nominal power:	100.0 kVA
Colled-oil type:	Vegetable (soybean-based)
Products covered:	100 kVA one-phase oil immersed distribution transformer
Geographical scope:	Brazil

Distribution Transformer



LCA information

Functional unit / declared unit:

A single piece of transformer operating for 35 years

Time representativeness:

January 2020 to December 2020

Database(s) and LCA software used:

SimaPro® software v.9.2 developed by PRé Consultants was used to create the product system model. The ecoinvent® database version 3.7.1 provided the life cycle background data for product system modelling.

System boundaries:

Cradle to grave with upstream, core and downstream modules;

Modules declared, geographical scope, share of specific data and data variation:

	Manufacturing			Distribution	Installation	Use and Maintenance	End-of-Life and Deinstallation
Module	**Upstream**		**Core**	**Downstream**			
Supply chain processes	extraction of raw materials and the production of semi-finished products and auxiliary items; electricity; production; transport of raw materials to Itaipu plant		transformer assembling, waste and effluent management at plant; air emissions from paint solvents	transformer transport into the operation site, installation and packaging waste management, operating for 35 years (RSL) in Brazil, deinstallation and transformer EoL, including metal recycling, vegetable oil treatment and final disposal of non-recyclable fractions at sanitary landfill. Transport of waste flows			
Modules declared	X	X	X	X	X	X	X
Geography	GLO	BR	BR	BR	BR	BR	BR
Specific data used	>95%						
Variation – sites	Not relevant						

Distribution:

The transformer is transported to São Paulo (south-eastern Brazil) by road transportation in diesel-powered lorries. The distance was estimated according to the most probable road from Itapolis plant until São Paulo Municipality, 400 km.

Installation:

The installation phase implies in the transportation of 50km of the tranformer and its packaging from energy company storage until the operation site. Then, the transformer is lifted and (generally) installed through manual/pneumatic tools. This phase also includes the disposal of the packaging of the Transformer, first returning until the energy company waste management central (50 km) and then tarnsported until the waste management compnay that co-process it into energy (200km).

Use stage:

The total energy consumed by the 100kVA transformer during 35 RSL is 210,833.49 kWh (losses and operational consumptions). This value was calculated according to IEC 60076-1 technical standard, expressed in kWh via the following equation (PCR0018 v.3.5).

$$E_d[kWh] = [P_{load} \times K^2{}_{load} + P_{noload}] \times t_{years} \times RSL + P_{aux} \times f_{aux} \times t_{years} \times RSL$$

End-of-Life:

EoL stage assumes that the discontinued equipment is sent for material recovering. The disassembling process is manual or done with the aid of pneumatic tools at the secondary metal recovering market. Most

valuable fractions (steel, aluminium and copper) are recycled within the default recycling recovering rate established in BSI EN 50693:2019. Vegetable oil is treated without energy recovering and the remaining parts, based on mass balance, are sent to sanitary landfill. Based on direct consultation and project assumptions the transport distances from energy company storage into the to disassembly facility is 100km, from disassembly facility to recycling plant and to the oil treatment company is 200 km, meanwhile the range into a landfill is 50 km.

Table 1. End-of-life baseline scenario definition per functional unit (downstream module).

Processes		Value	Unit
Collection process	From energy company storage to recovering market	602.70	kg
Recovery system specified by type	Reuse	0.00	kg
	Recycling	357.77	kg
	Incineration for energy recovery	0.00	kg
Disposal specified by type	Product or material for final deposition	133.00	kg
	Incineration	0.00	kg
	Vegetable oil wastewater treatment	111.93	kg
Assumption for scenario development	Assuming that 100% of the transformer is sent for disassembling (based on direct consultation with energy company), assuming that 80% of steel is recycled, 70% of aluminium is recycled, 60% of cooper parts are recycled (G.5 section from BSI EN 50693:2019 - Default values for R2) and that the vegetable oil is treated as refining oil wastewater treatment. Following mass balance principle and brazilian environmental laws, the remaining parts of the product are sent for final disopsal at sanitary landfills		

Allocation:

Allocation can be defined as the impact factors distribution between the reference product and the coproducts when they are simultaneous and dependent. At Itaipu value chain there is one type of situation where allocation may be required located at three points in end-of-life processes (i.e., the recycling processes) that occurs: at assembling line (core module) due to process waste generation, at transformer installation step (downstream module) due to wooden packaging waste generation that follows for energy recovering and at EoL (downstream module) due to metal recovering from obsolete transformers. Additionally, inputs and outputs at core module were disaggregated and apportioned to the 6923-211460A Transformer based on total production over 2020, accounted as kVA, which also may be considered as a physical allocation approach. In this rationale, smaller products with smaller nominal power demand less inputs and generate less outputs whereas the contrary also applies, with larger products with higher number of kVA will represent larger consumptions and generations.

- **Data apportion at assembling line:** based on the total production plant capacity in kVAs produced over 2020 at Itaipu manufacturing lines, adjusted by the 6923-211460A Transformer, i.e., 100kVA.

- **Assembling line, Installation and EoL**: regarding to the recycling of steel, silicon-steel, copper and aluminium generated during transformer manufacturing, as well as wood waste from packaging sent for energy recovering (co-processing) and recycled fractions at transformer EoL, we considered the cut-off approach. According to the core EPDItaly core-PCR (PCR007), for recovery and recycling processes, which take place outside the boundaries of the product system, only impacts related to the transport of the waste to the treatment platform should be considered. Therefore, all the impacts of the waste transportation by road were fully attributed to the Itaipu product.

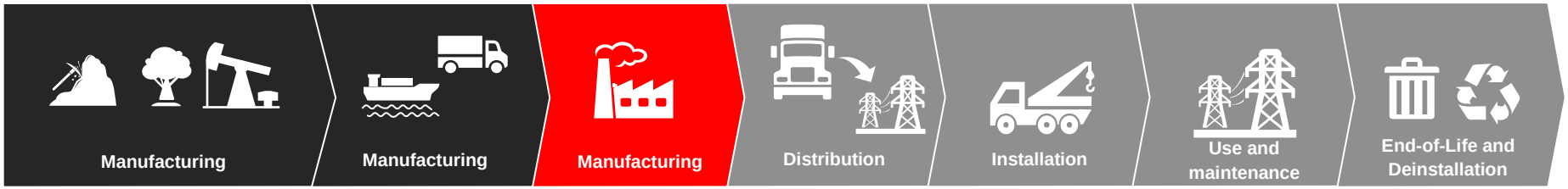
Cut-off criteria:

The cut-off criteria are applied to support an efficient calculation procedure. According to EN 50693 (2019) and PCR018 (2021), specifically the following flows and operations may be cut-off:

- Production, use and disposal of the packaging of components and semi-finished intermediates;
- Materials making up the transformer itself whose total mass does not exceed 1% of the total weight of the device;
- Material and energy flows related to dismantling phase, whenever it is reasonable to assume that dismantling is performed by adopting manual tools (e.g., screwdrivers, hammers, etc.);
- Devices external to the product itself required for installation;
- Maximum 5% of the overall environmental impact of the analysed product system;

In this LCA, all input and output flows have been considered at 100%, including raw materials as per the product composition provided by the manufacturer as well as the final product. Cut-off criteria was the environmental relevance for infrastructure impacts, although some irrelevant inputs may eventually not be considered, e.g., the cardboard used to clean the moulding machine. For inbound logistics, mass-based cut-off criteria was applied for minor components (screws, washers, rivets, etc). The coverage of inbound logistics was of 99.6% of mass composition for the transformer. At core module, emissions potentially arising from welding processes were cut-off.

Description of the system boundaries:



Upstream module

The distribution transformer is majorly made of steel and silicon-steel, aluminium/copper, paper/paperboard and oil (tank filled for cooling purposes). There are also minor parts of polymers, chemicals (painting, glue…), cotton, rubber and wood for packaging. The upstream module considers all upstream processes to extract such materials and process them into the final components that are inserted into Itaipu manufacturing line, including auxiliary consumptions at the factory such as electricity and others. This stage of the life-cycle accounts for the road and maritime transport of all materials and components from suppliers to Itaipu plant (inbound logistics).

Core module

The distribution transformer manufacturing is an assembling line. Metal sheets are cut, bended, calendared, moulded and welded into the final distribution transformer structure (tank, lid and bars). Those parts are cleaned and painted. In parallel, the core is made of silicon-steel and assembled from several different pieces that are cut to be geometrically positioned into the magnetic core that is wrapped with wildings prepared with insulated conductor wires and covered with insulating paper. Core and transformer body meet at the final assembling, with connections, cables and other minor parts and are tested for security, functioning and tightness. After packaging, the transformer is stored and ready for shipment. The manufacturing line at Itaipu plant requires ancillary inputs, such as electricity and water to operate and generate wastes and othe outputd. Electricity consumed at Itaipu plant is 100% from renewable source (hydro) meanwhile the major part of wastes are recycled following the internal policies on waste management.

Downstream module

This module encompass all steps after product expedition from Itaipu manufacturing plant until its End-of-life (EoL). The Transformer is distributed to São Paulo state by large diesel-truck through road transportation. The installation requires a lifting device that works for transport (from energy company storage into the operation point) and to elevate and install the transformer. During 35 years of Reference Service Life (RSL) the distribution transformer will convert energy voltage for urban consumption and consumes medium voltage electricity from brazilian national grid to operate and through losses in the transformation. During this period, an inspection should be made every 12 months of transformer operation to check for leakages, corrosion, and others. Every 5 years, some tests should be made as for example, oil sample for quality analysis, insulating check, etc. If there are no anomalies, no maintenance is necessary. According to Itaipu product specialists, in Brazil many transformers operate until its failure and maintenance is not a controlled practice. When discontinued, a distribution transformer is generally disassembled for metal recovering due to its high aggregated value. In Brazil this may be done at secondary scrap market or by specialized recycling companies. Steel, aluminium, copper and other metallic fractions are recovered and reinserted into the market. Other fractions are more likely to be discarded to sanitary landfill following Brazilian environmental laws. Vegatable oil may be recycled or treated in waste management specialized companies depending on its quality when discarded.

Content information

Product components	Material classes*	Weight, kg	Weight-% (versus the product)
Other ferrous alloys, non-stainless steel	M-119	381.77	56.75%
Aluminium and its alloys	M-120	74.69	11.10%
Copper and its alloys	M-121	0.12	0.02%
Stainless steel	M-100	0.47	0.07%
Tin and its alloys	M-126	2.00	0.30%
Other non-ferrous metals and alloys	M-149	2.50	0.37%
Paper/paperboard	M-341	16.52	2.46%
Wood	M-340	0.58	0.09%
Ceramics	M-160	8.41	1.25%
Oils and greases	M-410	111.93	16.64%
Chemicals (paints, varnish, dilutant, glues)	-	2.57	0.38%
Polyamide	M-208	0.42	0.06%
SBR	M326	0.45	0.07%
Fibre, Other organics	M-342 and M-399	0.28	0.04%
TOTAL	**-**	**602.70**	**89.59%**
Packaging materials	**Material classes****	**Weight, kg**	**Weight-% (versus the product)**
Wooden bars	M-340	70	10.41%
TOTAL	**-**	**70**	**10.41%**

**According to IEC 62474 - Material Declaration for Products of and for the Electrotechnical Industry;*

Substances of very high concern (SVHC)

These products contain no substances of very high concern (SVHC) on the REACH Candidate List published by the European Chemicals Agency in a concentration that exceed 0.01% (w/w).

Environmental Information

Potential environmental impact – mandatory indicators according to core-PCR

Results per a single piece of transformer operating for 35 years								
		Manufacturing stage		Distribution stage	Installation stage	Use and Maintenance stage	End-of-Life and deinstallation stage	Total
Indicator	unit	upstream	core	downstream				
GWP-fossil	kg CO_2 eq	3.12E+03	1.22	19.94	7.22	3.66E+04	39.00	3.97E+04
GWP-biogenic*	kg CO_2 eq	-451.56	1.12E-03	1.41E-02	5.18E-03	2.03E+04	46.67	1.99E+04
GWP-luluc	kg CO_2 eq	468.71	1.68E-05	2.63E-04	9.65E-05	3.22E+03	2.64E-03	3.69E+03
GWP-total	kg CO_2 eq	3.13E+03	1.22	19.96	7.22	6.01E+04	85.68	6.33E+04
ODP	kg CFC11 eq	1.69E-04	2.79E-07	4.49E-06	1.65E-06	3.50E-03	8.69E-06	3.69E-03
AP	mol H+ eq	22.51	8.27E-03	1.37E-01	4.89E-02	288.16	0.26	311.12
EP-freshwater	kg P eq	0.33	2.88E-06	4.62E-05	1.69E-05	0.63	2.46E-02	0.98
POCP	kg NMVOC eq	13.34	9.72E-03	1.61E-01	5.74E-02	106.36	0.33	120.27
ADP-minerals & metals**	kg Sb eq	6.21E-02	7.22E-08	1.16E-06	4.27E-07	1.07E-03	3.20E-06	6.32E-02
ADP-fossil**	MJ	3.26E+04	17.36	279.37	102.55	5.29E+05	543.70	5.63E+05
WDP**	m^3 depriv.	418.48	8.04E-03	9.17E-02	3.36E-02	2.24E+03	0.59	2.66E+03
Acronyms	GWP-fossil = Global Warming Potential fossil fuels; GWP-biogenic = Global Warming Potential biogenic; GWP-luluc = Global Warming Potential land use and land use change; ODP = Depletion potential of the stratospheric ozone layer; AP = Acidification potential, Accumulated Exceedance; EP-freshwater = Eutrophication potential, fraction of nutrients reaching freshwater end compartment; POCP = Formation potential of tropospheric ozone; ADP-minerals & metals = Abiotic depletion potential for non-fossil resources; ADP-fossil = Abiotic depletion for fossil resources potential; WDP = Water (user) deprivation potential, deprivation-weighted water consumption.							

** Negative GWP-biogenic value associated to the upstream core at manufacturing stage occurs due to the embodied biogenic carbon at paper/paperboard, vegetable oil and wooden parts of the product (including packaging). Those values are expected to return to the atmosphere during the End-of-Life and deinstallation stage depending on the destination of each material. For transformer parts (i.e., paper/paperboard and wood chocks), within the degradation rate at sanitary landfill, a share of carbon is returned as biogenic carbon dioxide and biogenic methane. For vegetable oil, it is also expected some returning emissions during the oil-treatment. For the packaging, since it is sent for energy recovering and the allocation approach is cut-off, the product system does not account for the impacts or credits. Those emissions therefore will occur at the subsequent system that uses the energy. Thus, care should be taken into account when analysing this impact category.*

*** Disclaimer: The results of this environmental impact indicator shall be used with care as the uncertainties of these results are high or as there is limited experience with the indicator.*

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Use of resources

Results per a single piece of transformer operating for 35 years									
			Manufacturing stage		Distribution stage	Installation stage	Use and Maintenance stage	End-of-Life and deinstallation stage	Total
Indicator		unit	upstream	core	downstream				
Primary energy resources - Renewable	Use as energy carrier (PERE)	MJ, net calorific value	7.78E+03	2.27E-02	0.36	0.13	6.90E+05	2.49	6.98E+05
	Use as raw materials (PERM)	MJ, net calorific value	5.64E+03	0.00	0.00	0.00	0.00	0.00	5.64E+03
	Total (PERT)	MJ, net calorific value	1.34E+04	2.27E-02	0.36	0.13	6.90E+05	2.49	7.03E+05
Primary energy resources - Non-renewable	Use as energy carrier (PENRE)	MJ, net calorific value	3.58E+04	17.36	279.37	102.55	5.31E+05	543.70	5.67E+05
	Use as raw materials (PENRM)	MJ, net calorific value	27.19	0.00	0.00	0.00	0.00	0.00	27.19
	Total (PERNT)	MJ, net calorific value	3.59E+04	17.36	279.37	102.55	5.31E+05	543.70	5.67E+05
Secondary material (MS)		kg	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Renewable secondary fuels (RSF)		MJ, net calorific value	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Non-renewable secondary fuels (NRSF)		MJ, net calorific value	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Net use of fresh water (FW)		m3	16.16	1.46E-03	6.31E-03	0.00	163.51	2.50E-02	179.70

Waste production and output flows

Waste production

Results per a single piece of transformer operating for 35 years								
		Manufacturing stage	Distribution stage	Installation stage	Use and Maintenance stage	End-of-Life and deinstallation stage	Total	
Indicator	unit	upstream	core	downstream				
Hazardous waste disposed (HWD)	kg	0.00	1.87	0.00	0.00	0.00	0.00	1.87
Non-hazardous waste disposed (NHWD)	kg	0.00	0.00	0.00	0.00	0.00	244.93	244.93
Radioactive waste disposed (RWD)	kg	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Output flows

Results per a single piece of transformer operating for 35 years								
		Manufacturing stage	Distribution stage	Installation stage	Use and Maintenance stage	End-of-Life and deinstallation stage	Total	
Indicator	unit	upstream	core	downstream				
Materials for energy recovery (MER)	kg	0.00	0.00	0.00	70.00	0.00	0.00	70.00
Material for recycling (MFR)	kg	0.00	34.84	0.00	0.00	0.00	357.77	392.61
Components for reuse (CRU)	kg	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Exported thermal energy (ETE)	MJ	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Exported electricity energy (EEE)	MJ	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Additional information

Other certifications

Renewable electricity acquired according to Certificate de Energia Renovavel for the total amount consumed in 2020 (COMERC/SINERCONSULT, 2021)

References

BSI (2019) EN 50693:2019 – Product category rules for LCA of electronic and electrical products and systems. Final version, August 2019. British Standard.
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ISO (2006a) 14040: Environmental Management - Life Cycle Assessment - Principles and Framework.
ISO (2006b) 14044: Environmental Management - Life Cycle Assessment - Requirements and guidelines.

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