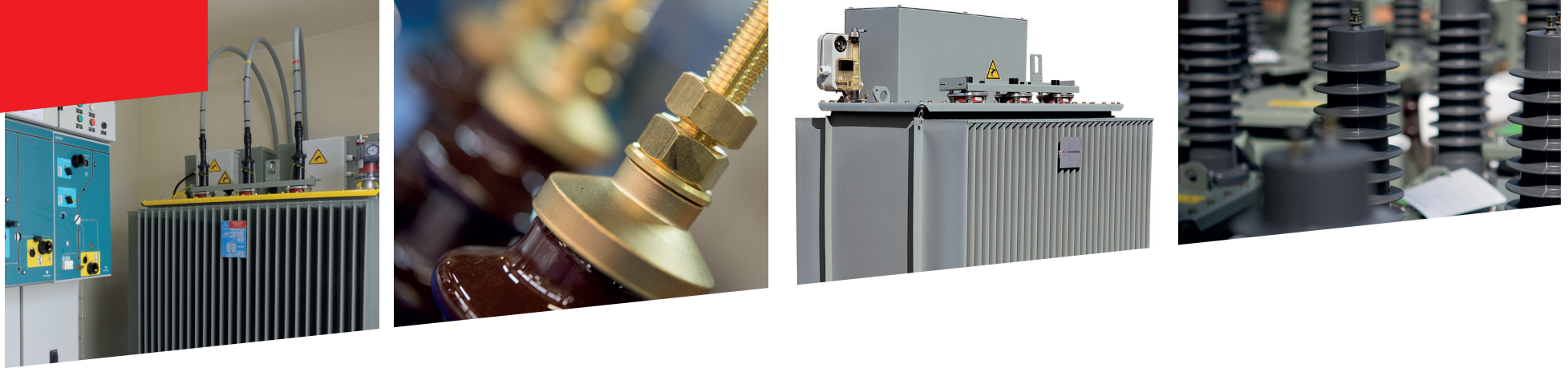


REDUCTION OF SMALL,
MEDIUM AND LARGE POWER
ELECTRICAL TRANSFORMER LOSSES

EcoDesign ErP Directive





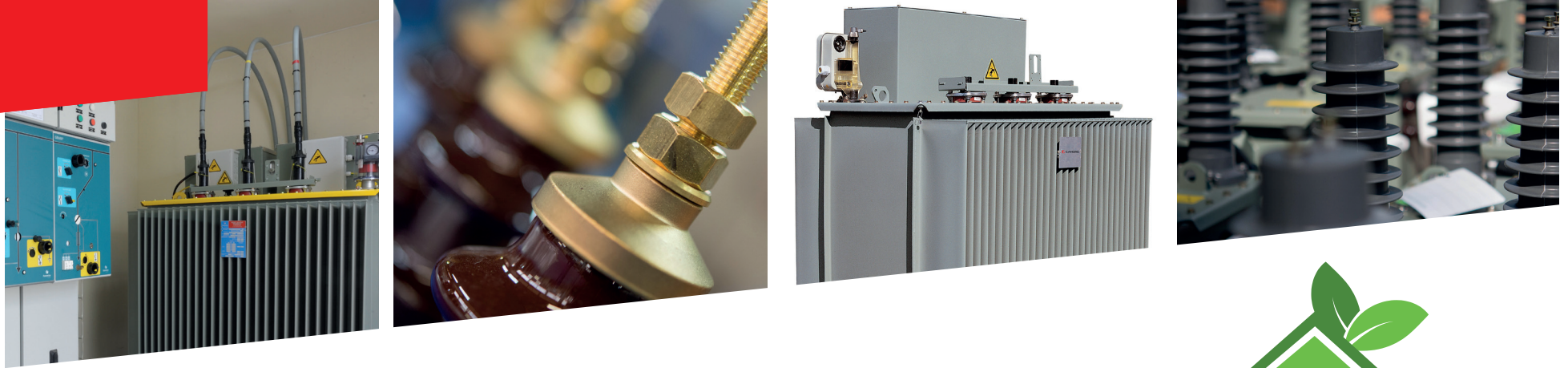
REFERENCE DOCUMENTS

»» European Union Regulation

No. 548/2014
of 21 May 2014

»» Standards

IEC 60076
Draft EN 50588 (formerly 50464)



A EUROPEAN AND NATIONAL COMMITMENT

How can we reduce greenhouse gas emissions by 20%

- ✓ **By controlling** primary energy consumption and **encouraging** the development of renewable energy.

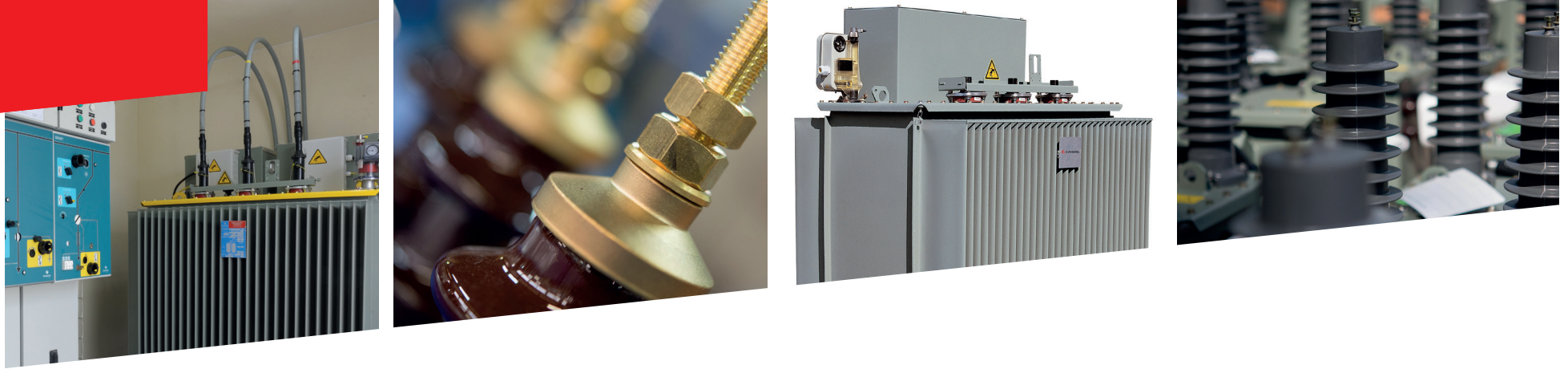


How are energy consumers becoming involved?

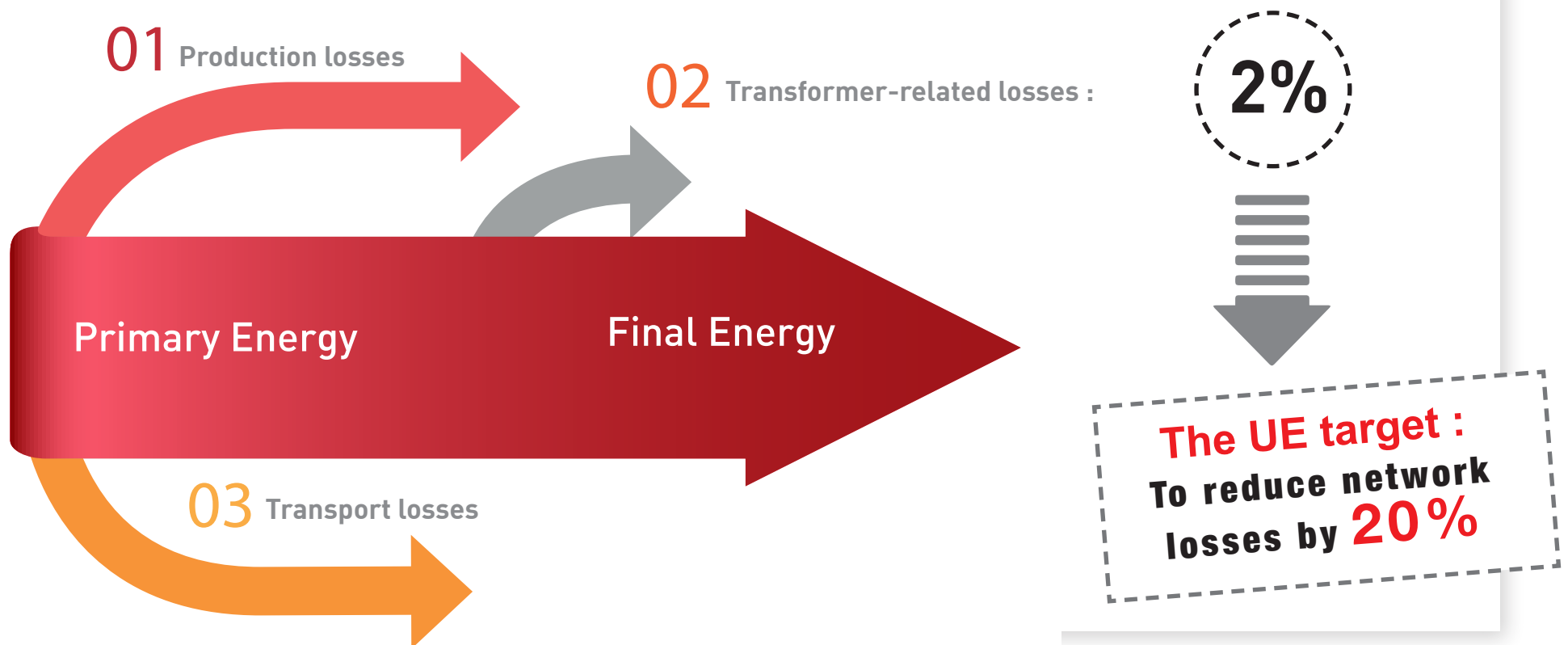
- ✓ **By applying the EcoDesign directive** and its measures **to reduce the energy consumption of :**

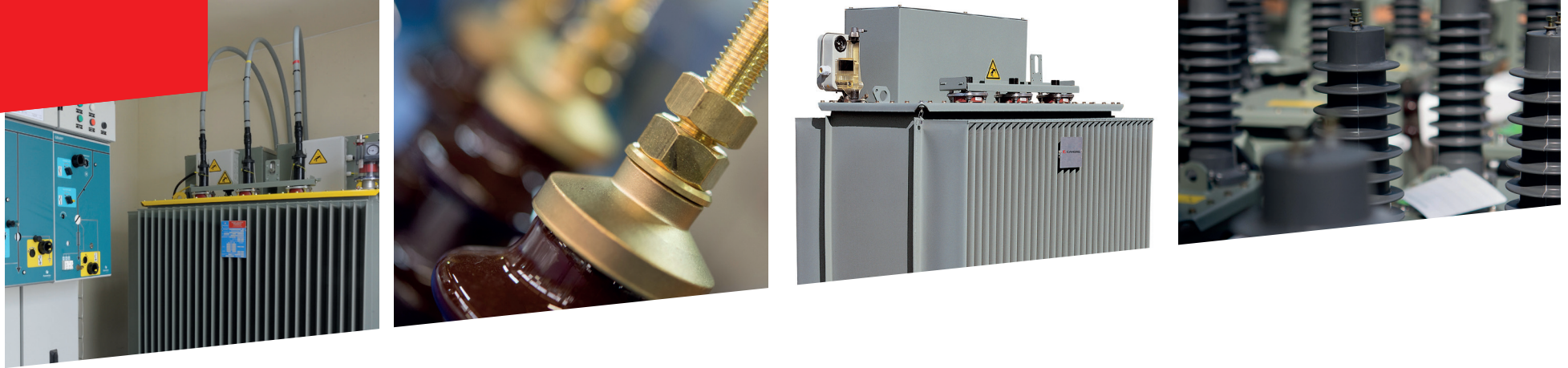
- Household appliances
- Cars
- Small, medium and large power transformers...





ELECTRICAL DISTRIBUTION PRINCIPLE



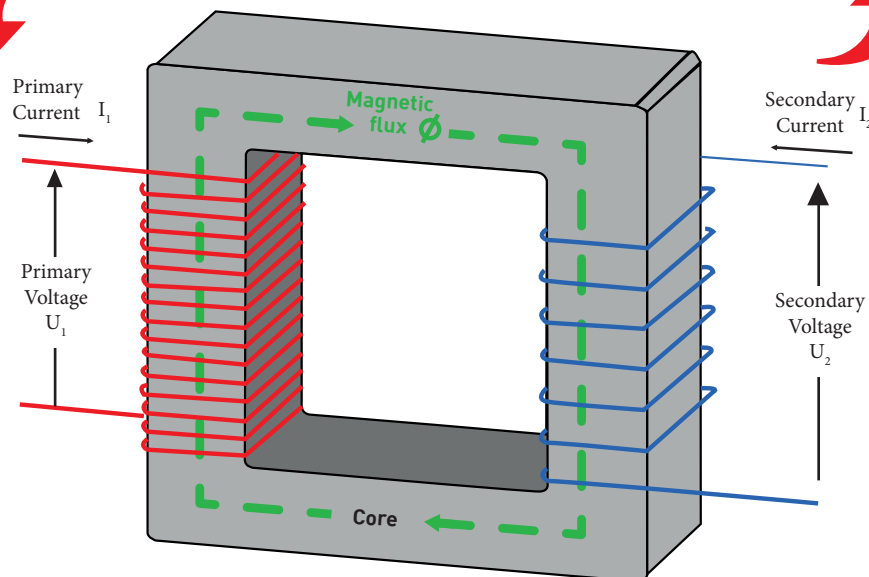


TRANSFORMER OPERATION

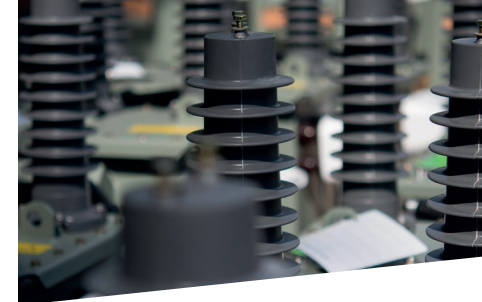
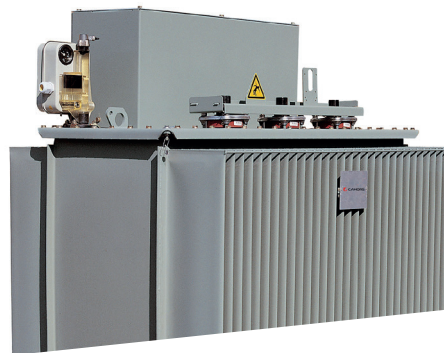
CONVERT WHILE CONSUMING THE LEAST POSSIBLE ENERGY

100% energy injected

98% finale energy delivered



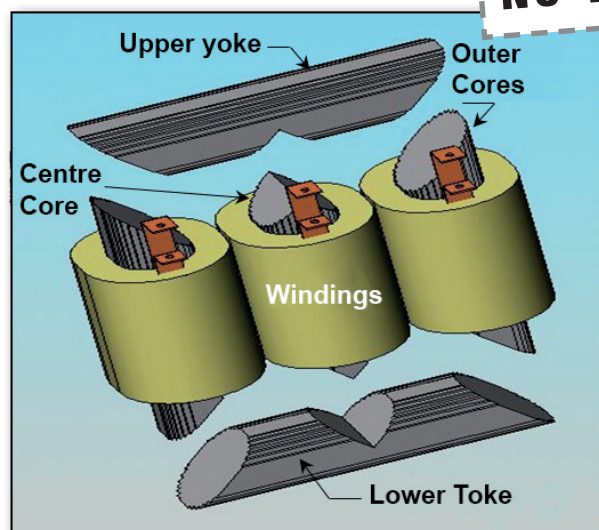
Today, a transformer dissipates **2% of its power on average** due to its operation.



HOW CAN TRANSFORMER LOSSES BE REDUCED ?

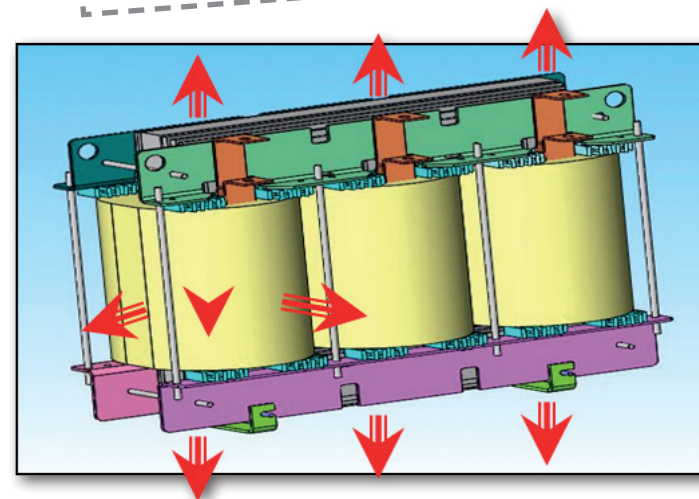
By improving the quality of the **electrical steel**, used for the magnetic circuit

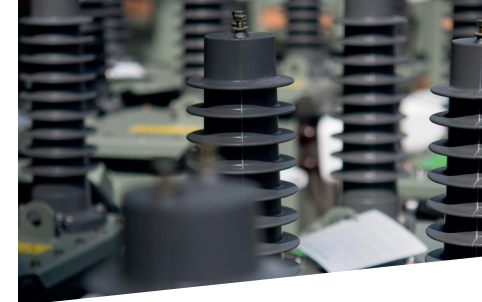
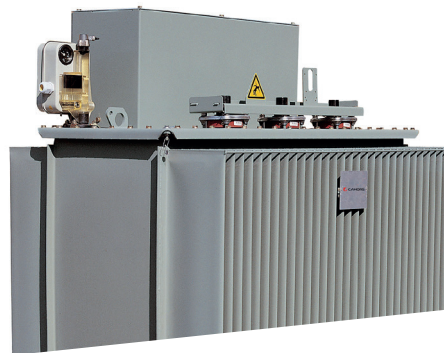
= REDUCE NO-LOAD LOSSES



By increasing the cross section of the **electrical conductors of the windings**

= REDUCE LOAD LOSSES





THE NEW EUROPEAN REGULATION

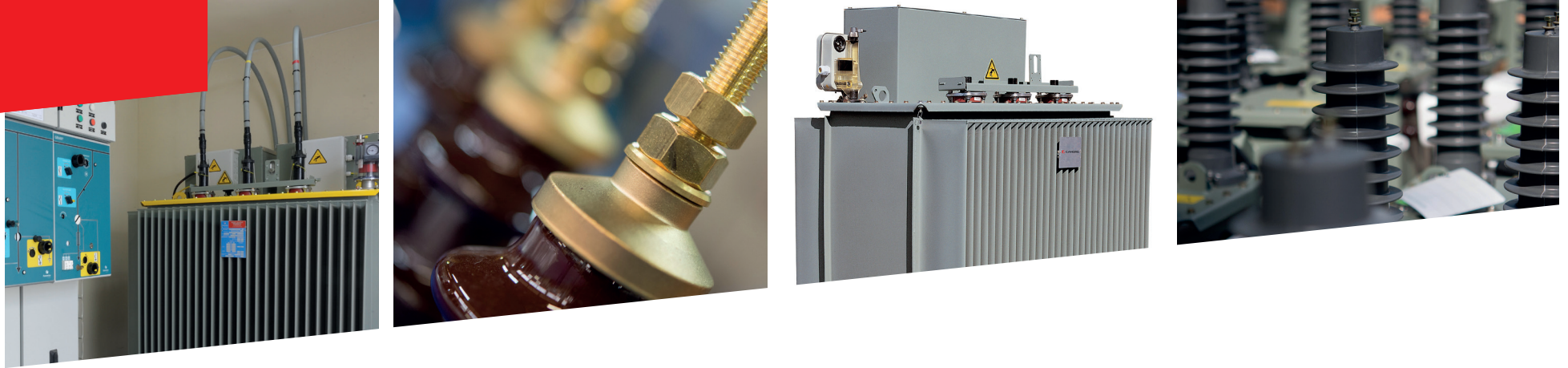
THIS NEW DIRECTIVE REQUIRES :

- 1 **Electrical losses to be reduced and their tolerances to be eliminated in accordance with :**
 - The minimum Ao, Ck or Bk classifications for transformers from **25 kVA to 3150 kVA**.
 - A **PEI ratio** (Peak Efficiency Index) for power transformers.
 - **More restrictive** criteria : elimination of the tolerances on losses.

- 2 A «CE» mark on the equipment

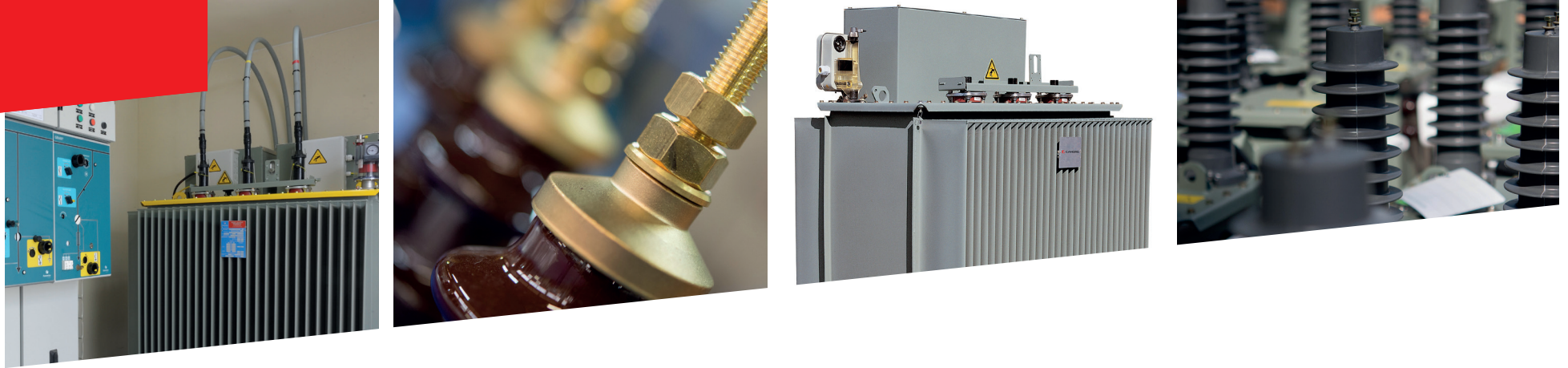


ZERO
TOLERANCE



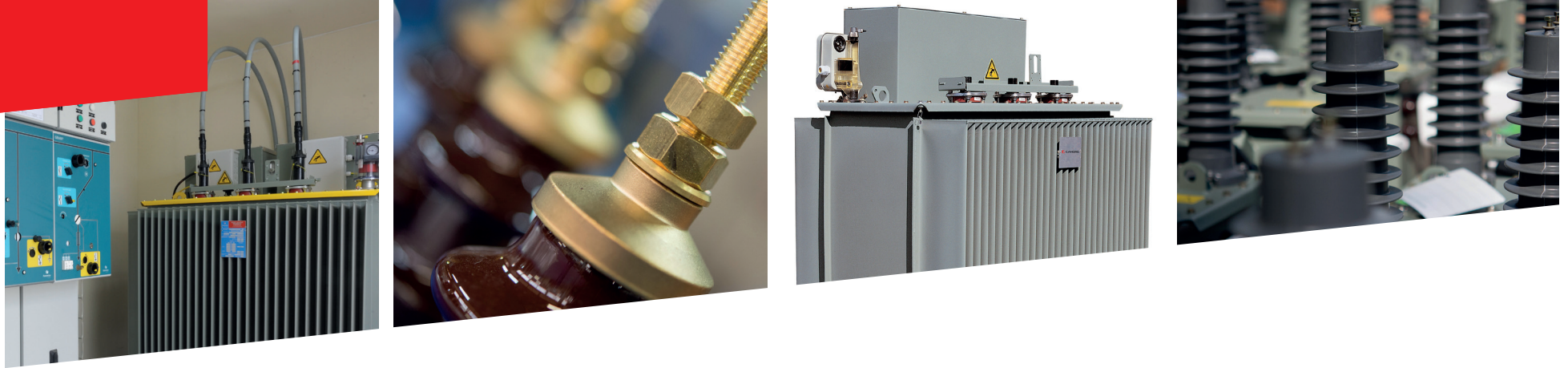
Example of losses for public distribution transformers

EN 50464 & EN 60076-13	Current	ECODESIGN 1 st stage	ECODESIGN 2 nd stage
100 kVA pole-mounted self-protected transformer	C0Dk	1 st July 2015 A0Ck	1 st July 2021 A0Bk
No-load losses (W)	210	-30% 145	145
Load losses (W)	2150	-20% 1750	-15% 1475
EN 50464			
400 kVA Cabin	C0Ck	1 st July 2015 A0Ck	1 st July 2021 A0 -10% Ak
No-load losses (W)	610	-30% 430	-10% 387
Load losses (W)	4600	4600	-30% 3250



Example of losses for oil-immersed type transformers for green tariff (off-peak use) private distribution

NF C 52-112	Current	ECODESIGN 1 st stage	ECODESIGN 2 nd stage
630 kVA Cabin	E0Ck	1 st July 2015 A0Ck	1 st July 2021 A0 - 10% Ak
No-load losses (W)	1300	-55% 600	-10% 540
Load losses (W)	6500	6500	-30% 4600
1250 kVA Cabin	D0Dk	1 st July 2015 A0Bk	1 st July 2021 A0 - 10% Ak
No-load losses (W)	1750	-45% 950	-10% 855
Load losses (W)	16 000	11 000	-30% 9500



LOSSES LEVELS

Type	Power (kVA)	Current losses	From 01/07/2015
Poles	25, 50 and 100 kVA	C0 Dk	A0 Ck
	160 kVA	D0 Dk	C0 Ck + 32%
Cabin	50 and 100 kVA	C0 Dk	A0 Ck
	160 kVA	D0 Dk	
	250 to 630 kVA	E0 Ck	
	800 and 1000 kVA	D0 Dk	
	> 1000 kVA	D0 Dk	A0 Bk
Dry-type (≤ 3150 kVA)	≤ 630	C0 Bk	A0 Bk
	> 630	C0 Bk	A0 Ak

Average energy saving for the French installed base:

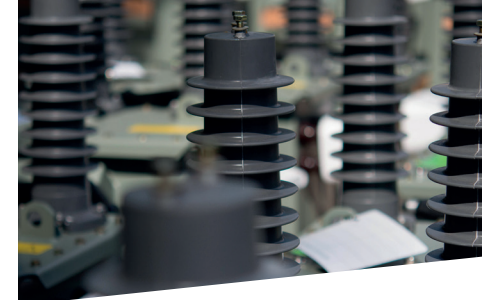
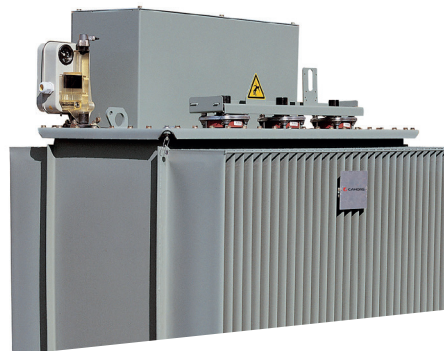
approximately - **20%** of total losses for oil-immersed type transformers



Average energy saving for the French installed base:

approximately - **15%** of total losses for dry-type transformers





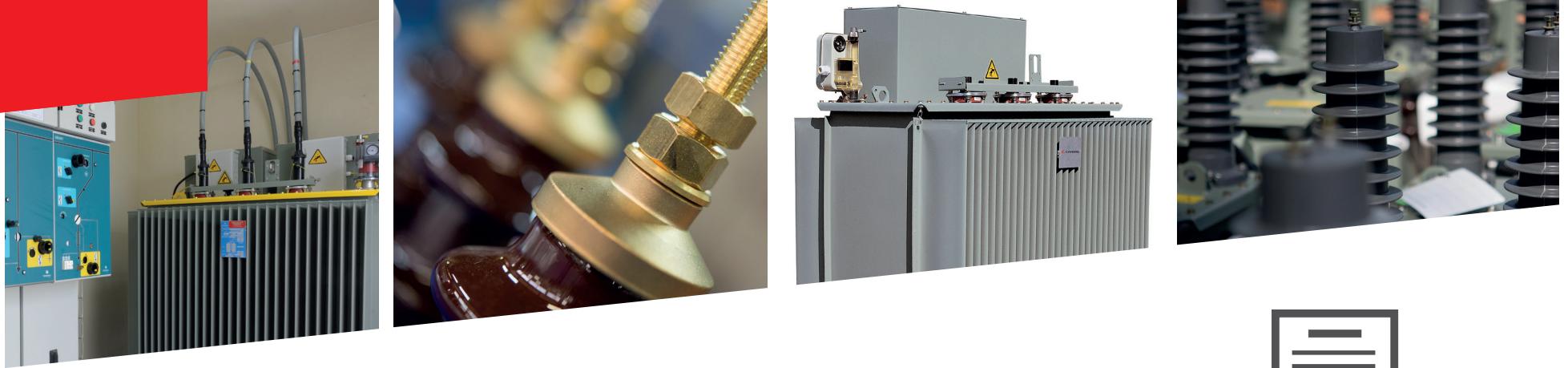
APPLICATIONS

✓ Who is concerned by this new directive?

- Secondary **distribution** networks (private or public networks)

✓ When does the new directive become applicable?





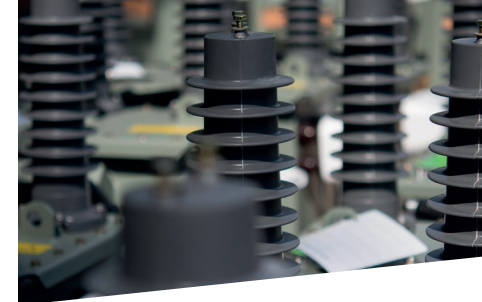
APPLICATIONS



✓ **The following transformers are not concerned by this new directive :**

- Three-phase earthing or grounding transformers with a neutral point and zero sequence generators,
- on-board traction transformers,
- starting transformers,
- testing transformers,
- welding transformers (for arc or resistance welding).

⌘⌘⌘ **Other transformers are concerned by this new directive. Please refer to Commission Regulation No. 548/2014 of 21 May 2014.**



SUMMARY

WHO IS CONCERNED ?



- **ALL EUROPEAN TRANSFORMER STATIONS**

There are nearly 4 000 000 HV/LV transformers installed in Europe

- **Public distribution networks** : ERDF (French electricity board), municipal authorities, state companies, consumers.
- **Private distribution networks** : The services sector and industry, producers : wind turbines, photovoltaic power, etc.

WHEN ?



- **1st JULY 2015**

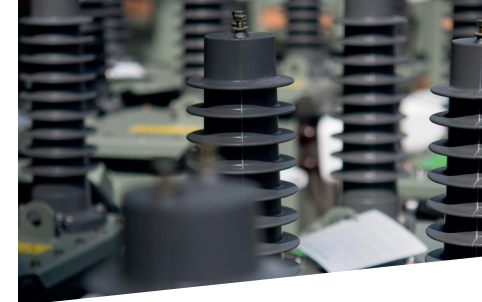
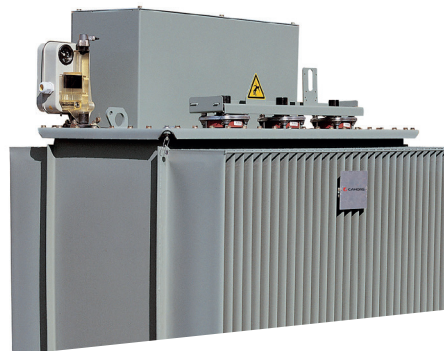
All transformers put into service

- Minimum A0 Ck or A0 Bk classification for oil-immersed type transformers (except pole-mounted transformers with a power $\geq 160\text{kVA}$)
- Minimum A0 Bk or A0 Ak classification for dry-type transformers

- **1st JULY 2021**

All transformers put into service

- Minimum A0- 10% Ak classification for oil-immersed type transformers
- Minimum A0- 10% Ak classification for dry-type transformers.

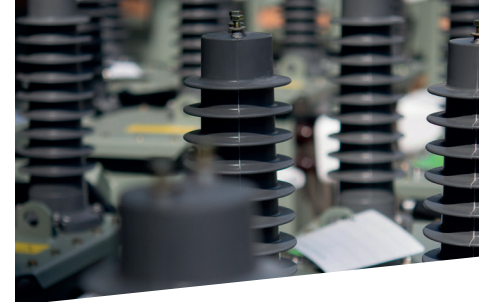
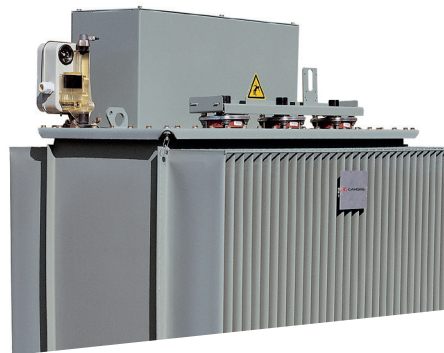


CAHORS MANUFACTURER COMMITMENT

CAHORS undertakes to respect the EcoDesign directive by manufacturing transformers that strictly comply with the technical specifications and requirements of standard EN 50588, with «CE» marking and checked by a certified and calibrated laboratory test.

CUSTOMER AND SPECIFIER COMMITMENT

Our customers undertake to order equipment from a manufacturer who complies with the EcoDesign directive. Installation of the equipment will be checked by an inspection organisation.



APPENDICES

Requirements for three-phase medium power transformers with rated power $\leq 3\,150$ kVA

Maximum load and no-load losses (in W) for three-phase **liquid-immersed medium power transformers** with one winding with $U_m \leq 24$ kV and the other winding with $U_m \leq 1,1$ kV.

	Tier 1 (from 1 st July 2015)		Tier 2 (from 1 st July 2021)	
Rated power (kVA)	Maximum no-load losses P_o (W) *	Maximum load losses P_k (W) *	Maximum no-load losses P_o (W) *	Maximum load losses P_k (W) *
≤ 25	Ao (70)	Ck (900)	Ao - 10 % (63)	Ak (600)
50	Ao (90)	Ck (1100)	Ao - 10 % (81)	Ak (750)
100	Ao (145)	Ck (1750)	Ao - 10 % (130)	Ak (1250)
160	Ao (210)	Ck (2350)	Ao - 10 % (189)	Ak (1750)
250	Ao (300)	Ck (3250)	Ao - 10 % (270)	Ak (2350)
315	Ao (360)	Ck (3900)	Ao - 10 % (324)	Ak (2800)
400	Ao (430)	Ck (4600)	Ao - 10 % (387)	Ak (3250)
500	Ao (510)	Ck (5500)	Ao - 10 % (459)	Ak (3900)
630	Ao (600)	Ck (6500)	Ao - 10 % (540)	Ak (4600)
800	Ao (650)	Ck (8400)	Ao - 10 % (585)	Ak (6000)
1000	Ao (770)	Ck (10 500)	Ao - 10 % (693)	Ak (7600)
1250	Ao (950)	Bk (11 000)	Ao - 10 % (855)	Ak (9500)
1600	Ao (1200)	Bk (14 000)	Ao - 10 % (1080)	Ak (12 000)
2000	Ao (1450)	Bk (18 000)	Ao - 10 % (1305)	Ak (15 000)
2500	Ao (1750)	Bk (22 000)	Ao - 10 % (1575)	Ak (18 500)
3150	Ao (2200)	Bk (27 500)	Ao - 10 % (1980)	Ak (23 000)



* Maximum losses for the rated powers in kVA that do not correspond to one of the values given in the table are determined by linear interpolation.

Requirements for three-phase medium power transformers with rated power $\leq 3\,150$ kVA

Maximum load and no-load losses (in W) for three-phase **dry-type medium power transformers** with one winding with $U_m \leq 24$ kV and the other winding with $U_m \leq 1,1$ kV.

Rated power (kVA)	Tier 1 (from 1 st July 2015)		Tier 2 (from 1 st July 2021)	
	Maximum no-load losses P_o (W) *	Maximum load losses P_k (W) *	Maximum no-load losses P_o (W) *	Maximum load losses P_k (W) *
≤ 50	Ao (200)	Bk (1700)	Ao - 10 % (180)	Ak (1500)
100	Ao (280)	Bk (2050)	Ao - 10 % (252)	Ak (1800)
160	Ao (400)	Bk (2900)	Ao - 10 % (360)	Ak (2600)
250	Ao (520)	Bk (3800)	Ao - 10 % (468)	Ak (3400)
400	Ao (750)	Bk (5500)	Ao - 10 % (675)	Ak (4500)
630	Ao (1100)	Bk (7600)	Ao - 10 % (990)	Ak (7100)
800	Ao (1300)	Ak (8000)	Ao - 10 % (1170)	Ak (8000)
1000	Ao (1550)	Ak (9 000)	Ao - 10 % (1395)	Ak (9000)
1250	Ao (1800)	Ak (11 000)	Ao - 10 % (1620)	Ak (11 000)
1600	Ao (2200)	Ak (13 000)	Ao - 10 % (1980)	Ak (13 000)
2000	Ao (2600)	Ak (16 000)	Ao - 10 % (2340)	Ak (16 000)
2500	Ao (3100)	Ak (19 000)	Ao - 10 % (2790)	Ak (19 000)
3150	Ao (3800)	Ak (22 000)	Ao - 10 % (3420)	Ak (22 000)



* Maximum losses for the rated powers in kVA that do not correspond to one of the values given in the table are determined by linear interpolation.

Requirements for three-phase medium power transformers with rated power > 3 150 kVA

Minimum Peak Efficiency Index (PEI) values for **liquid-immersed medium power transformers**.

	Tier 1 (from 1 st July 2015)	Tier 2 (from 1 st July 2021)
Rated power (kVA)	Minimum Peak Efficiency Index value (%)	
3150 < Sr ≤ 4000	99,465	99,532
5000	99,483	99,548
6300	99,510	99,571
8000	99,535	99,593
10 000	99,560	99,615
12 500	99,588	99,640
16 000	99,615	99,663
20 000	99,639	99,684
25 000	99,657	99,700
31 500	99,671	99,712
40 000	99,684	99,724



Requirements for three-phase medium power transformers with rated power > 3 150 kVA

Minimum Peak Efficiency Index (PEI) values for **dry-type medium power transformers**.

	Tier 1 (from 1 st July 2015)	Tier 2 (from 1 st July 2021)
Rated power (kVA)	Minimum Peak Efficiency Index value (%)	
3150 < Sr ≤ 4000	99,348	99,382
5000	99,354	99,387
6300	99,356	99,389
8000	99,357	99,390
≥ 10 000	99,357	99,390



Requirements for medium power transformers with rated power $\leq 3\,150$ kVA, equipped with tapping connections suitable for operation while transformer is energised or on load for voltage adaption purposes. The voltage regulation distribution transformers are included in this category.

»»» The specified maximum allowable levels of losses should be increased by 20% for no-load losses and by 5% for load losses in Tier 1, and by 10% for no-load losses in Tier 2.

Requirements for medium power pole-mounted transformers.

»»» Maximum load and no-load losses (in W) for **medium power liquid-immersed pole-mounted transformers**.

Rated power (kVA)	Tier 1 (from 1 st July 2015)		Tier 2 (from 1 st July 2021)	
	Maximum no-load losses P_o (W) *	Maximum load losses P_k (W) *	Maximum no-load losses P_o (W) *	Maximum load losses P_k (W) *
25	Ao (70)	Ck (900)	Ao (70)	Bk (725)
50	Ao (90)	Ck (1100)	Ao (90)	Bk (875)
100	Ao (145)	Ck (1750)	Ao (145)	Bk (1475)
160	Co (300)	Ck + 32% (3102)	Co - 10 % (270)	Ck + 32% (3102)
200	Co (356)	Ck (2750)	Bo (310)	Bk (2333)
250	Co (425)	Ck (3250)	Bo (360)	Bk (2750)
315	Co (520)	Ck (3900)	Bo (440)	Bk (3250)



* Maximum losses for the rated powers in kVA that do not correspond to one of the values given in the table are determined by linear interpolation.

Minimum energy efficiency requirements for large power transformers

➤➤➤ Minimum Peak Efficiency Index (PEI) requirements for **liquid-immersed large power transformers**.

	Tier 1 (1 st July 2015)	Tier 2 (1 st July 2021)
Rated power (MVA)	Minimum Peak Efficiency Index value (%)	
≤ 4	99,465	99,532
5	99,483	99,548
6,3	99,510	99,571
8	99,535	99,593
10	99,560	99,615
12,5	99,588	99,640
16	99,615	99,663
20	99,639	99,684
25	99,657	99,700
31,5	99,671	99,712
40	99,684	99,724
50	99,696	99,734
63	99,709	99,745
80	99,723	99,758
≥ 100	99,737	99,770



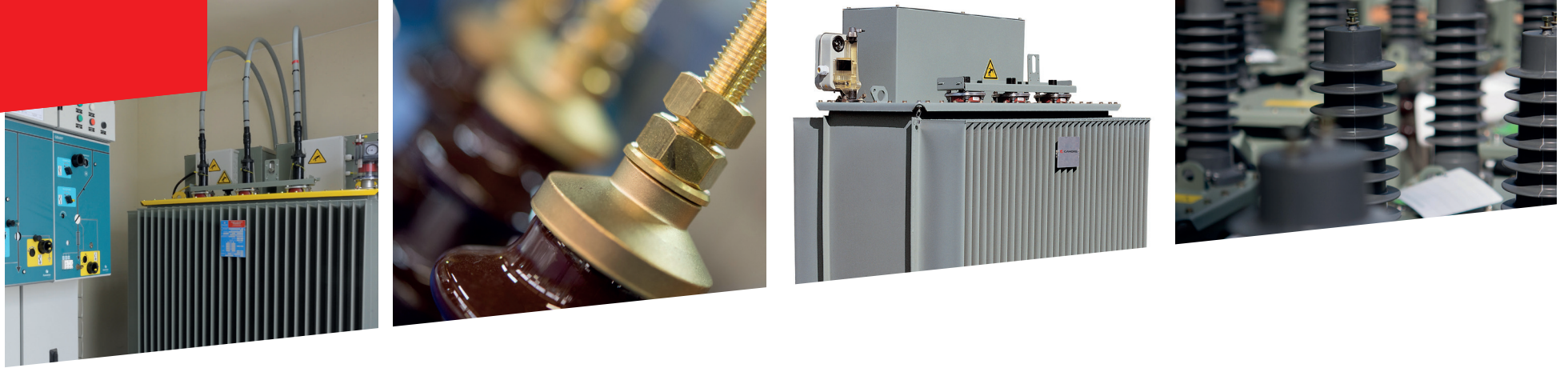
Minimum energy efficiency requirements for large power transformers

Minimum Peak Efficiency Index (PEI) requirements for **dry-type large power transformers**.

	Tier 1 (1 st July 2015)	Tier 2 (1 st July 2021)
Rated power (MVA)	Minimum Peak Efficiency Index value (%)	
≤ 4	99,158	99,225
5	99,200	99,265
6,3	99,242	99,303
8	99,298	99,356
10	99,330	99,385
12,5	99,370	99,422
16	99,416	99,464
20	99,468	99,513
25	99,521	99,564
31,5	99,551	99,592
40	99,567	99,607
50	99,585	99,623
≥ 63	99,590	99,626







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