

Low Loss Distribution Transformers in a South African Context



Gareth Stanford, Gary Jones & Sakier Whiting

Introduction: Why reduce loss?



- Eskom generation shortage
- Cost of electricity
- Reduction of CO2 emissions
- Green energy tariffs
- Finite reserve of fossil fuel
- Time to market of generation



Distribution Transformer Specifications

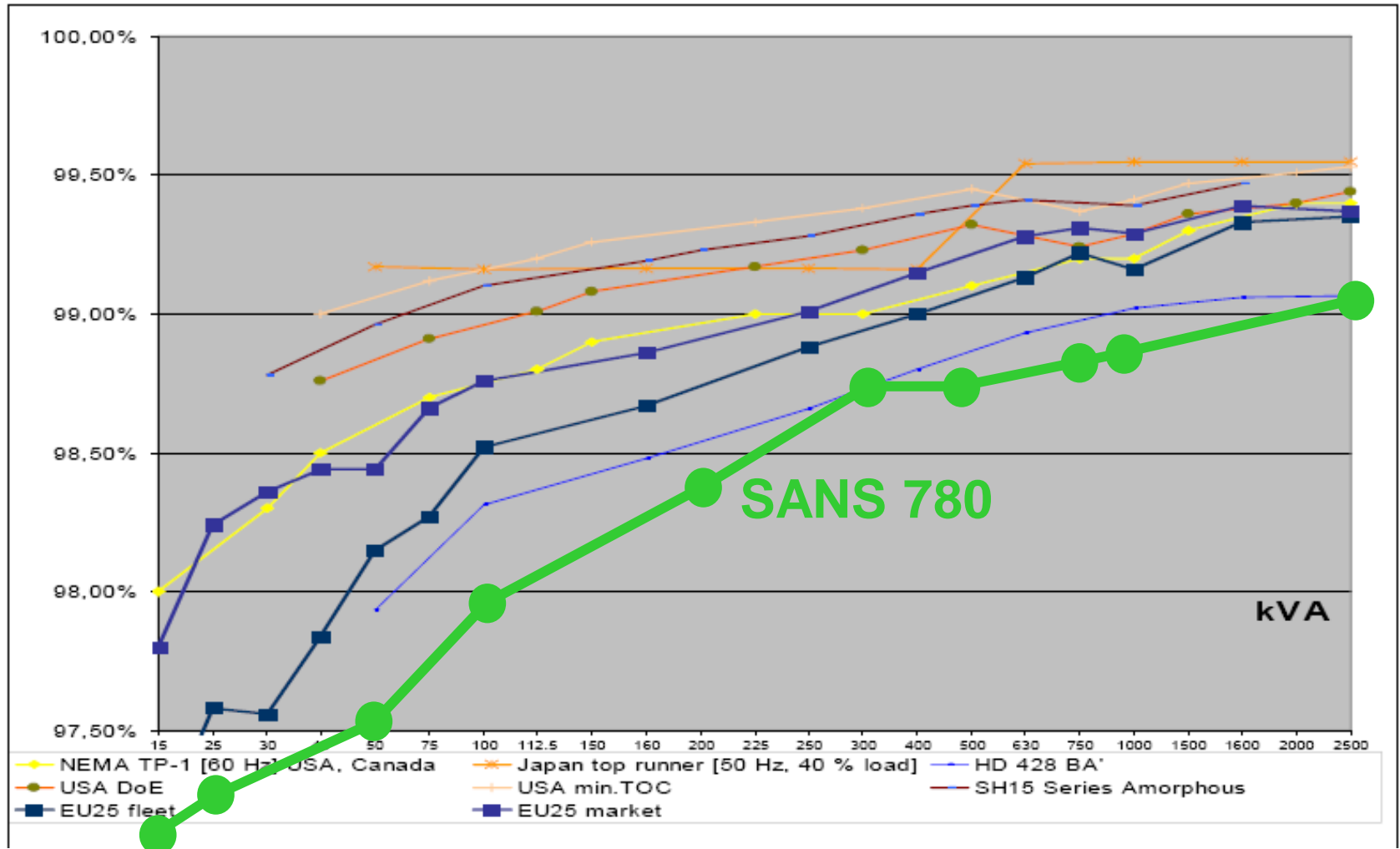


Table 1 — Standard power ratings and standard component losses of dual-ratio transformers (other than auto-transformers)

1	2	3	4	5	6
Rated no-load secondary voltage V	Rated power kVA	Component losses			
		No-load loss W			Load loss W
		Up to 12 kV	24 kV	36 kV	
121 or 242, single-phase	5	40	—	—	160
	16	80	100	—	400
	25	110	140	160	530
	50	180	220	250	900
420 or 550, three-phase	16	95	120	—	410
	25	120	150	170	570
	50	180	220	250	1 000
	100	300	360	400	1 700
	200	520	600	650	2 700
	315	720	840	890	3 800
	500	1 100	1 180	1 230	5 400
	630	1 300	1 400	1 450	6 400
	800	1 600	1 650	1 700	8 000
	1 000	1 900	1 950	2 000	9 500
	1 250	2 250	2 300	2 350	11 000
	1 600	2 750	2 770	2 820	13 500
2 000	3 250	3 250	3 300	16 000	
3 300 or 3 450, three-phase	2 500	3 800	3 800	3 800	19 000
	3 150	4 500	4 500	4 500	22 000

- Most users specify SABS 780:2009
- No Load Loss
- Load Loss

International Benchmarking



Are Cap Formulas the answer?



- Cap cost = Total cost of ownership
- Costs factors depend on cost of energy & life span
- Total cost = Price + No load loss cost + Load Loss cost

	≤ 200 kVA	315 kVA	500 kVA	≥ 800 kVA
Utility 1		$F_{NL} =$ $F_L =$	31 200 R/kW 6 700 R/kW	
Utility 2		$F_{NL} =$ $F_L =$	56 430 R/kW 11 789 R/kW	
Utility 3		$F_{NL} =$ $F_L =$	58 062 R/kW 12 529 R/kW	
Utility 4 (R/kW)	$F_{NL}=91104$ $F_L = 27331$	$F_{NL} = 91104$ $F_L = 36441$	$F_{NL} = 113880$ $F_L = 45552$	$F_{NL} = 113880$ $F_L = 68328$

Transformer Evaluation



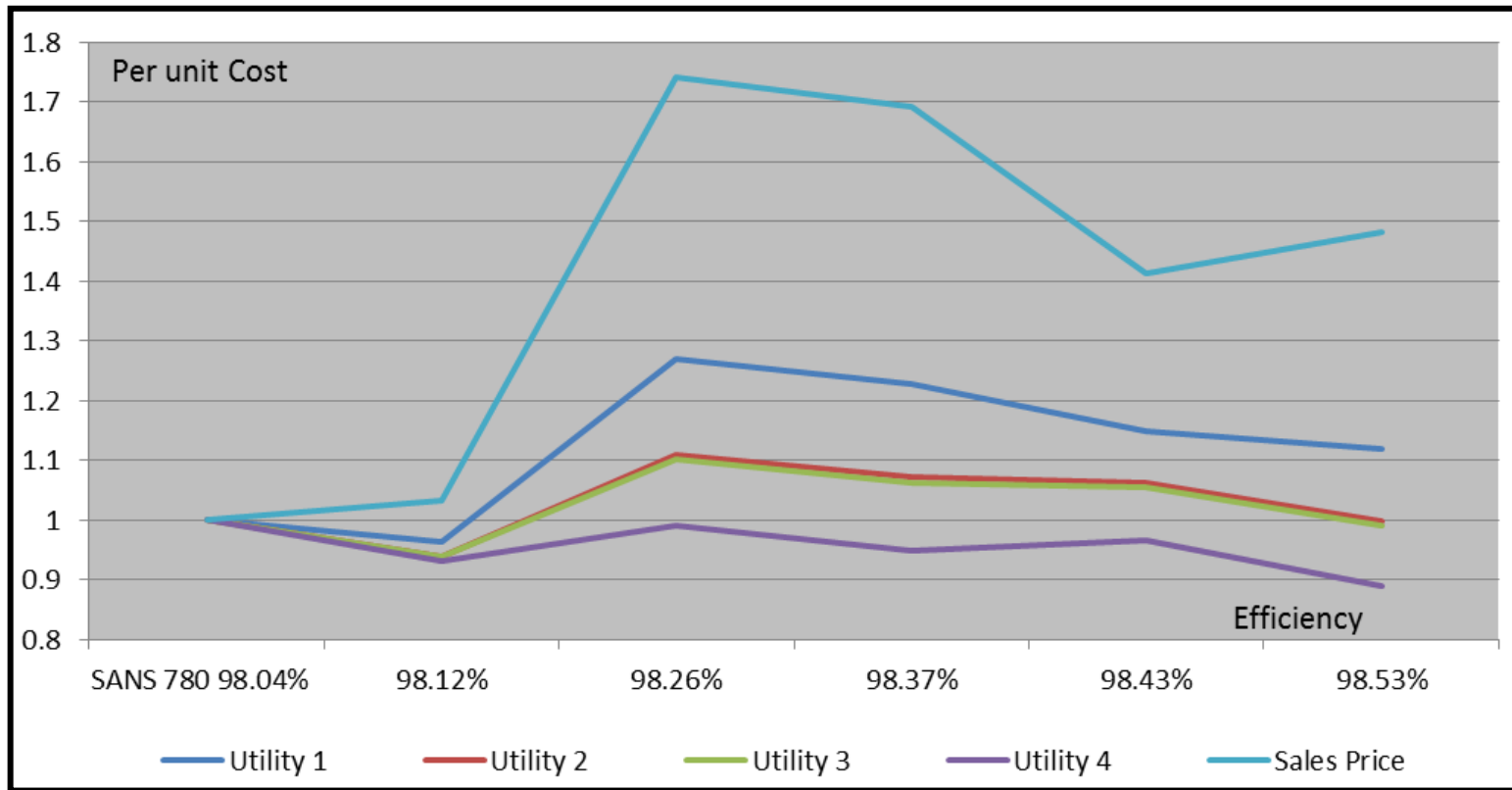
- 100 kVA 11 kV transformers
- Convert to per unit using SANS a base value.

Transformer data					Utility 1	Utility 2	Utility 3	Utility 4
Design	Transformer Efficiency	NLL kW	LL kW	Sales	TCO	TCO	TCO	TCO
SANS 780	98.04%	0.3	1.7	1	1	1	1	1
Reduced Loss GO1	98.12%	0.22	1.7	1.03	0.9635	0.939	0.939	0.932
Low Loss AM1	98.26%	0.07	1.7	1.74	1.2686	1.11	1.101	0.991
High Efficiency AM2	98.37%	0.08	1.6	1.69	1.2272	1.071	1.062	0.949
High Efficiency GO2	98.43%	0.25	1.4	1.41	1.1488	1.062	1.055	0.966
Extra Low Loss GO3	98.53%	0.14	1.4	1.48	1.119	0.998	0.99	0.89

Evaluation Results



- Sales price increases as efficiency improves.
- Long term saving assumes finances are available for the increase in sale price.



Further Loss Improvement



- Reduction losses \approx increased materials
 \approx bigger transformer
 \approx heavier transformer
 \approx expensive transformer
 \approx expensive installation
- Ideal transformer \approx reduced loss
 \approx reduced materials
- Capitalisation formula allows Cost verses Benefit analysis as technology improves.
- Allowing an incremental approach to reducing losses