



vito

vision on technology

09/07/2009

Stakeholder meeting

**Sustainable Industrial Policy – Building on the Ecodesign
Directive – Energy-Using Product Group Analysis/1**

LOT 2: Distribution and power transformers

Agenda

- » Presentation of participants
- » MEEuP methodology by Biois
- » Task 1 by VITO (Paul)
- » Task 2 by VITO (Liesbet)
- » Task 3 by VITO (Liesbet –Paul)
- » Data needs and enquiry by VITO
- » Planning & feedback on reports
- » Any other business

Chapter 1: Definition – main ecodesign parameters

- » LCA > 14 environmental indicators
- » Ad hoc parameters:
 - » Noise
 - » Electromagnetic fields (EMF)
 - » Use of hazardous materials in transformers (Oil (PCB, Mineral), SF6 gas)

Chapter 1: Definition – main ecodesign parameters

- » LCA > 14 environmental indicators
- » Ad hoc parameters:
 - » Noise
 - » Electromagnetic fields (EMF)
 - » Use of hazardous materials in transformers (Oil (PCB, Mineral), SF6 gas)
- » Energy Efficiency > load (P_k) and no load losses (P_o) and Auxiliary Losses (P_{aux})
 - » *Other?*

Chapter 1: Definition – Categories

- » Types of categories:
 - » PRODCOM
 - » rated power (S)
 - » Technology
 - » Type of service
 - » *Any other?* Pole mount- oil (biodegradable-synthetic)

Chapter 1: Definition – Scope

Name	Application	Technology or functionality											Min kVA	Max kVA		
		Oil	Dry	Gas	MV/LV	HV and/or MV	Phase change	LV/LV auto	LV/LV isolation (separation)	LV/SELV (control)	Cu winding	Alu winding			High SC impedance (>5%)	Am-steel core
MV/LV Distribution transformer	Distribution by DSO	99,99%	0,01%		100%						90%	10%		<50	50	2500
line voltage restorers	Distribution by DSO		100%				100%				xx				10	50
DER LV/MV transformers	Connecting DER by producer	20%	80%		100%						80%	20%	90%	0%	50	2500
Industry MV/LV oil transformer	Distribution by non DSO (industry, ..)	50%			100%						85%	15%			50	2500
Industry MV/LV dry transformer	Distribution by non DSO (industry, ..)		50%		100%						15%	85%	95%		50	4000
Power transformer	Power by TSO (DSO)	100%		0%		99%					xx				5000	>
Phase	Power by TSO (DSO)	100%		0%			1%				xx				5000	>
Seperation/isolation transformer	Distribution by non DSO (industry, ..)		100%					xx			xx				1	63
Control transformer	Distribution by non DSO (industry, ..)		100%						xx	xx					0,04	2,5
Safety transformers	Industry application		100%						xx	xx					1	63
speciality transformers	Industry application	??	??		??	??					??	??	??	??	??	??

Chapter 1: Definition – First impact screening

Name	Avg kVA	Stock 2005 (Kunits)	sales (units)	Pk Avg (sales 2005) Watt	PoAvg (sales 2005) Watt	Pk (Avg % load raw estimate)	Estimated TWh	Pk BAT Watt	Po BAT Watt	Pk (Avg % load raw estimate)	Estimated TWh
MV/LV Distribution transformer	250	3600	140400	3250	650	117	24	2350	300	84,835	12
line voltage restorers	25	??	??	??	??	??	??	??	??	??	??
DER LV/MV transformers	2000	20	2900	??	??	??	??	??	??	??	??
Industry MV/LV oil transformer	630	800	43200	6500	1300	1040	16	4600	600	166,06	5
Industry MV/LV dry transformer	800	170	8047	10000	2500	1600	6	6500	1600	234,65	3
Power transformer	100000	64,4	1803	300000	80000	12000	52	300000	80000	12000	52
Phase	100000	0,65	17	300000	80000	12000	0	300000	80000	12000	1
Seperation/isolation transformer	25	??	??	??	??	??	??	??	??	??	??
Control transformer	1	??	??	??	??	??	??	??	??	??	??
Safety transformers	25	??	??	??	??	??	??	??	??	??	??
speciality transformers	??	??	??	??	??	??	??	??	??	??	??

Chapter 1: Definition – Scope

- » Background market&use data > Chapter 2&3
- » Issues:
 - » Power transformers: 52 TWh is about 1.5 % of 3100 TWh?
 - » Smaller industrial transformers:
 - » Smaller industrial transformers used in distribution:
 - » Separating/isolating transformer
 - » Control transformer (24 VAC)
 - » Smaller industrial transformers used with industrial applications:
 - » Safety transformers (lot 7)
 - » Speciality transformers (welding, ..?)
- » *Lack of data on smaller transformers? Improvement potential in transformer product? Improvement potential at system level (e.g. power electronic solutions)?*

Chapter 1: Definition – Performance parameters

- » Primary: Transformer rated power (S)
- » Secondary energy efficiency related: No load losses (P_0), Load losses (P_k), Auxiliary losses (P_{aux})
- » Secondary application related: Load Factor ($\alpha = P_{avg}/S$), Load form factor ($K_f = \frac{P_{rms}}{P_{avg}}$), Transformer availability factor (AF), Power factor (PF), K-factor.
- » Secondary functional related: Short-circuit impedance, Rated voltage of the high-voltage winding (V_{rms}), Rated voltage of the low-voltage winding (V_{rms}), LwA dB (A), Vector group, Insulation temperature class, Protection class (IP), Fire behaviour class, Environmental class, Climate class.
- » *Complete for the study?*
- » *Functional Unit: proposal 'Transformer rated power (S)' (correct in text)*

Standards – Test EN

- » European (EN) Test Standards on Energy Use
 - » EN 60076-1 (IEC 60076-1) ‘Power transformers. General’
 - » EN 50464 series under the general title “Three-phase oil-immersed distribution transformers 50Hz, from 50 kVA to 2500 kVA with highest voltage for equipment not exceeding 36kV”
- » European (EN) Test Standards on other ecodesign parameters

Performance parameter or Ecodesign parameter	Standard	Status/notes	Gap identified
<i>LwA dB (A): Sound power level of the transformer</i>	IEC 600769-10??		?
EMF (electromagnetic field)	To complete		?
Hazardous substances PCB	To complete		?
Hazardous substances PCB	To complete		?
Hazardous substances PCB	To complete		?
ANY OTHER RELEVANT?			?
			?

Chapter 1: Test Other&conclusion

- » Input required: Sector, National, Third country
- » Note: 'rated power' (S) definition differs IEC (EU) from IEEE (US)
- » *Conclusion: There are no missing standards?*

Chapter 1: Other relevant standards for the study – related to energy use or ecodesign parameters

- » Table 1.6 (not in the right place in the text)
- » EN 50464 series (oil filled distribution transformers)
 - » four classes for the load losses (Ak to Dk) and five classes for no-load losses (A0 tot E0).
- » HD 538.1 series (dry type distribution transformers)
 - » Maximum level

Chapter 1: Other relevant standards for the study

» To be completed:

Performance parameter or Ecodesign parameter	Standard	Status/notes	Gap identified
<i>Short-circuit impedance</i>	IEC 60076-1 (EN)		?
<i>Rated voltage of the high-voltage winding (V_{rms})</i>	IEC 60076-1 (EN)		?
<i>Rated voltage of the low-voltage winding (V_{rms}):</i>	IEC 60076-1 (EN)		?
<i>Insulation temperature class</i>	IEC 60085 (EN)		?
<i>Protection class (IP)</i>	EN 60529		?
<i>Fire behaviour class</i>	IEC 60076-11 (Dry type transformers)		?
<i>Environmental class</i>	IEC 60076-11 (EN)		?
<i>Climate class</i>	IEC 60076-11 (EN)		?
ANY OTHER RELEVANT?			?

Chapter 1: Existing legislation and agreements

- » EU: Machinery (No), ROHS (No), WEEE (No), Directive 2004/40/EC on the minimum health and safety (system), Directive 89/106/EEC construction products (?), Directive 2005/32/EC on Eco-design (= study). *PCB ban?*
- » Agreements EN: EN 50464 series, HD 538.1 series, SEEDT, *Any other?*
- » Relevant Legislation at Member State level. *Any? PCB ban?*
- » Third Country
 - » Note:
 - » European, most African and Asian: within 10% of 230 V at 50 Hz
 - » Japan, North America and some parts of South America: 100 and 127 V at 60 Hz
 - » Hence: grid different (size transformers), other losses

Chapter 1: Third countries

- » Many have MEPS for distribution transformers
- » China has MEPS for power transformers (<31,5 MVA)
- » Stakeholders are welcome to provide relevant input.
- » Other smaller industry transformers?

Chapter 2: Economic and Market Analysis

- » Aim:
 - » Generic economic data
 - » Insights in past, recent and future stock and market
 - » Additional parameters
 - » Market trends
 - » User expenditure data

Chapter 2: Economic and Market Analysis

» Generic economic data

» Europroms-Prodcom statistical data show:

- » LV dry industry largest market
- » MV oil industry second largest market
- » Distribution third largest market
- » Power smallest share

» Market trend (market and growth) correlates with data literature and sector organisation, however not in number of units

» Explanation:

- » Broader scope statistical data than literature (also small industrial transformers)
- » BUT, inconsistencies statistical data: more units imported, but greater monetary value produced?

Chapter 2: Economic and Market Analysis

- » Eurostat seems unreliable and not in line with figures other reports and sector data
 - other economic and market sources used
- » Data retrieved from:
 - » Literature
 - » Sector organisation
 - » Your input (especially on small transformers) and feedback!

Chapter 2: Economic and Market Analysis

» Economic data retrieved till now: **STOCK**

Transformer type	Stock	Stock	Stock
	1990	2005	2020
	<i>K units</i>	<i>K units</i>	<i>K units</i>
MV/LV Distribution transformer (oil)	2 692	3 600	4 459
line voltage restorers	?	?	?
DER LV/MV transformers	0.25	20	90
Industry MV/LV oil transformer	598	800	991
Industry MV/LV dry transformer	127	170	211
Power transformer	48	64.35	80
Phase	0.49	0.65	0.81
Separation/isolation transformer (dry)	?	?	?
Control transformer (dry)	?	?	?
Safety transformers (dry)	?	?	?
Speciality transformer	?	?	?

Chapter 2: Economic and Market Analysis

- » **Economic data** retrieved till now: **MARKET** – estimated growth
 - » Sales new installation: estimation based on electricity consumption 1990-2005 and predictions for 2020 (=same method for STOCK 1990 and 2020)
 - » Replacement sales: estimation based on economic product life time
 - » Distribution 40 years
 - » Large industry oil 25 years
 - » Large industry dry 30 years
 - » Small industry dry 10 years
 - » Power 70 years

Chapter 2: Economic and Market Analysis

» Economic data retrieved till now: **MARKET** – estimated growth

Transformer type	New installed sales		Replacement sales
	1990-2005	2005-2020	
	<i>% p.a.</i>	<i>% p.a.</i>	<i>% p.a.</i>
MV/LV Distribution transformer (oil)	1.9	1.4	2.5
line voltage restorers	1.9	1.4	2.5
DER LV/MV transformers	34	10.5	4
Industry MV/LV oil transformer	1.9	1.4	4
Industry MV/LV dry transformer	1.9	1.4	3.3
Power transformer	1.9	1.4	1.4
Phase	1.9	1,4	1.4
Separation/isolation transformer (dry)	1.9	1.4	10
Control transformer (dry)	1.9	1.4	10
Safety transformers (dry)	1.9	1.4	10
Speciality transformer (?)	1.9	1.4	10

Chapter 2: Economic and Market Analysis

» **Economic data** retrieved till now: **MARKET** – estimated figures

Transformer type	Total sales		
	1990	2005	2020
	<i>units p.a.</i>	<i>units p.a.</i>	<i>units p.a.</i>
MV/LV Distribution transformer (oil)	118 443	140 400	173 891
line voltage restorers	?	?	?
DER LV/MV transformers	95	2 900	13 050
Industry MV/LV oil transformer	35 294	43 200	53 505
Industry MV/LV dry transformer	6.652	8 047	9.966
Power transformer	1 588	1 802	2 232
Phase	16	18	23
Separation/isolation transformer (dry)	?	?	?
Control transformer (dry)	?	?	?
Safety transformers (dry)	?	?	?
Speciality transformer (?)	?	?	?

Chapter 2: Economic and Market Analysis

- » **Additional MEEuP market parameters**
 - » Transformer design
 - » Energy efficiency
 - » Total inhabitants EU27
 - » Electricity use EU27

Chapter 2: Economic and Market Analysis

- » **Additional MEEuP market parameters**
 - » *Transformer design*
 - » Almost all transformers have Si-steel cores (0.0001% amorphous cores)
 - » 80-90% Cu windings and 10-20% Al windings

Chapter 2: Economic and Market Analysis

» Additional MEEuP market parameters

» Energy efficiency

<i>Sector</i>		<i>Average rating (kVA)</i>	<i>Average no-load loss (W)</i>	<i>Average load loss (W)</i>
<i>MV/LV distribution oil</i>	stock	250	650	3250
	sales	400	750	4600
<i>Industry oil</i>	stock	630	1300	6500
	sales	1000	1700	13000
<i>Industry dry</i>	stock	800	2500	10000
	sales	1250	2800	13100
<i>Power</i>	stock	100000	80000	300000
	sales	100000 ?	80000	300000
<i>DER</i>	stock	2000	?	?
	sales	2000	?	?
Small industrial transformers	stock	1-25	?	?
	sales	1-25	?	?

Chapter 2: Economic and Market Analysis

- » **Additional MEEuP market parameters**
 - » Transformer design
 - » Energy efficiency
 - » *Total inhabitants EU27 from Eurostat*
 - » *Electricity use EU27 per sector from Eurostat*

Chapter 2: Economic and Market Analysis

» Market trends

- » Trend to increase stock of residential distribution transformers
- » Trend to increase stock of distribution transformers in decentralised renewable energy production
- » Trend towards more power transformers in offshore farms
- » Trend towards more power transformers used in EU interconnection lines

Chapter 2: Economic and Market Analysis

- » **Market trends**
- » Duration of redesign cycle:
 - » 3 to 12 months if production with same production lines
 - » 3 to 5 years if production lines need to be changed

Chapter 2: Economic and Market Analysis

- » User expenditure data
 - » Need for data → enquiry

Chapter 3: User behaviour

- » Aim:
 - » Analysis of consumer behaviour: user information and barriers for eco-design
 - » Analysis of real life situation:
 - » real efficiency – energy use
 - » harmonics and ambient temperature
 - » end-of-life

Chapter 3: User behaviour

- » **User information - Potential barriers for eco-design measures**
 - » Lack of awareness on environmental impact of transformers
 - » Lack of users acceptance for higher cost and pay back time
 - » Lack of information on energy efficiency
 - » Lack on information on dimensional physical aspects

- » Other ?

Chapter 3: User behaviour

- » Analysis of real life situation: real efficiency – energy use
 - » Use phase
 - » Real life efficiency → load profiles
 - » Load profiles characterised by
 - » load form factor
 - » load factor
 - » power factor
 - » availability factor

Chapter 3: User behaviour

- » Analysis of real life situation: real efficiency – energy use
 - » Use phase: load form, moad and power factor

Application	Load form factor	Load factor	Power
Distribution	1.073	0.19	0.95
Industry	1.096	0.40	
Power	1.08	0.20	
DER (wind)	1.60	0.30	
Small transformers	1.096	0.40	

Chapter 3: User behaviour

- » Analysis of real life situation: real efficiency – energy use
 - » Use phase: availability factor

Application	AF (typ.)	AF (min.)	AF (max.)
distribution	1	1	1
industry	1	1	1
power	1	1	1
DER (wind)	1	0.5	1
small industry	0.25	0.12	1

Chapter 3: User behaviour

- » Analysis of real life situation: harmonics and ambient temperature
 - » Harmonics : losses due to non-linear loads
 - use of highest efficiency transformers
 - » Ambient temperature: resistance Cu and Al increases with $\nearrow T^\circ$
 - load losses can increase/decrease

→ NOT taken into account as impact relative to chosen reference

Chapter 3: User behaviour

- » **Analysis of real life situation: End-of-life**
 - » **Repair:**
 - » **rewind of transformer coils**
 - » **Rebocking and reclamping of the coils**
 - » **Repacement of ancillary equipment (fans, pumps, pressure relief,...)**
 - » **Recyling and replacement**
- **99% dismanteled and recycled, others repaired**

Following actions

- » Enquiry forms will be sent out
- » Comments on the chapters 1-3 (next day small corrections with remark of the meeting)
- » Comments on other chapters
- » Data for chapter 4&5 (enquiries to industry)
- » Deliverables and timing

Timing –target dates

Task	Draft for comment	Comment	Final
1	22/7	7/9	30/9
2	22/7	7/9	30/9
3	22/7	7/9	30/9
4	10/11	15/12	
5	10/11	15/12	
6			
7			30/6/10