Intelligent Energy Europe

Energy-efficient distribution transformers in industry and commerce

eceee

4 June 2009

Strategies for development and diffusion of **E**nergy **E**fficient **D**istribution **T**ransformers

January 2006 - June 2008

Wolfgang Irrek,
Wuppertal Institute,
Germany

Roman Targosz,
PCPC, Poland

Frangiskos V. Topalis,
NTUA, Greece

What was SEEDT?

SEEDT was an European IEE project which aimed at:

- Promoting the use of energy-efficient Distribution Transformers (DT)
- Proposing and applying strategies for reducing energy losses in DTs

SEEDT project partners were:

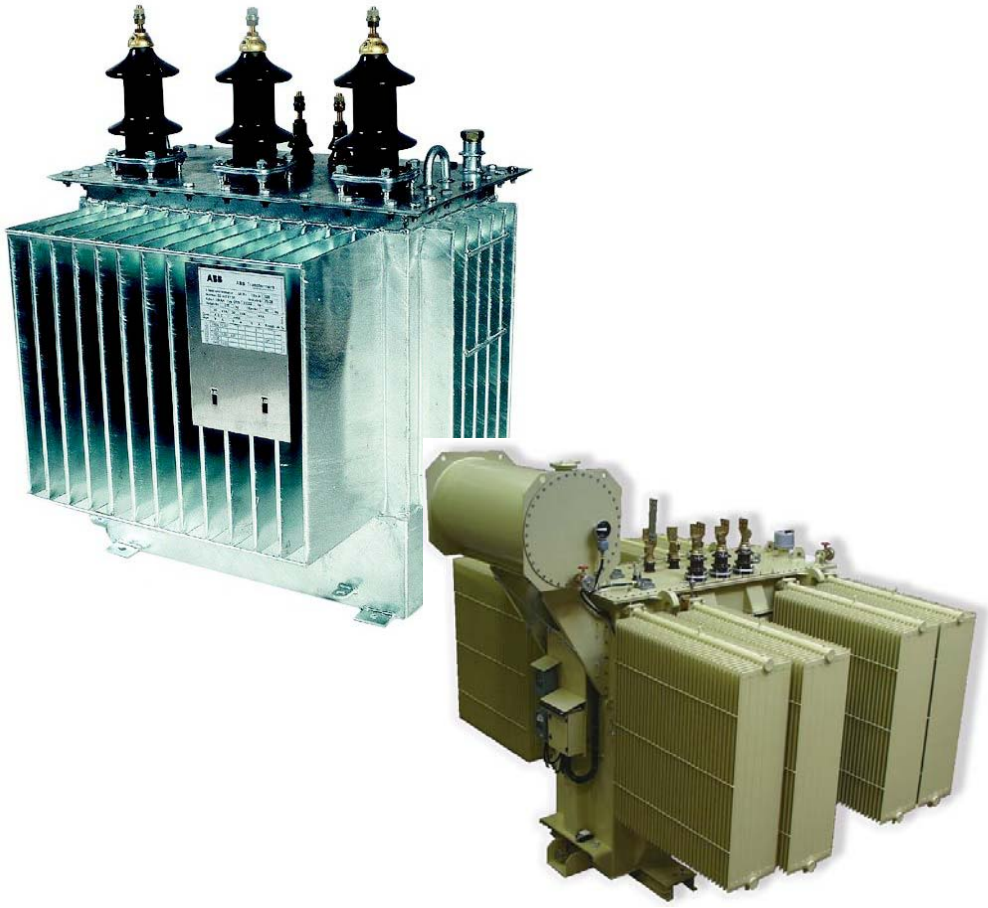
NTUA-Greece, **WUPPERTAL INSTITUTE**–Germany,
ADEME–France, **AERE**–France, **ENDESA**–Spain, **FAST**–Italy,
PCPC–Poland, **AREVA T&D**–Poland, **LZE S.A.**-Poland

SEEDT focus today at eceee 2009:

- DTs in **industry and commerce**

Distribution transformers

- Transforming electricity at medium voltage level (typically 10 kV to max. 36 kV, 3 phase system) to low voltage level (most typically 400 V, in general up to 1 kV)
- Nominal power: 50 kVA - 2500 kVA



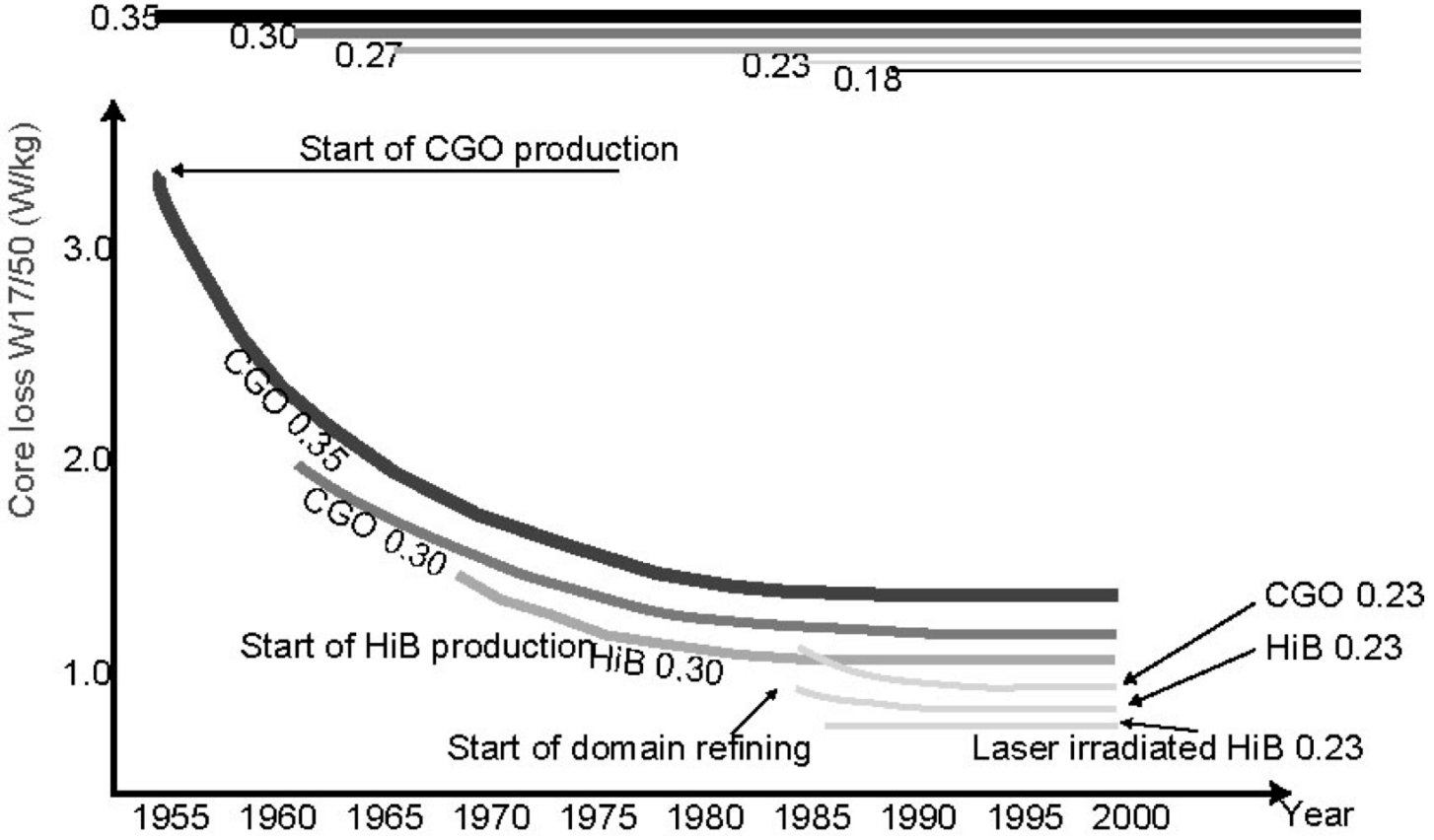
Starting point: Distribution transformer population, market sales and losses in 2004 – EU-27

Owner	Number in fleet (millions)	Number of pcs sold in market	Non-load losses in fleet (TWh/year)	Load losses in fleet (TWh/year)
Electricity distribution companies	3.7	85,000	16.0	6.0
Industrial - liquid-filled transformers	**0.8**	**38,000**	**5.5**	**2.2**
Industrial - dry-type transformers	**0.2**	**16,000**	**2.6**	**1.1**
Total	4.6	140,000	24.1	9.3

Technical options to reduce load and non-load losses

- Applying improved cold rolled grain oriented (CGO) steel, with improved cutting technology and decreased lamination thickness of 0.23 mm
- Optimisation of windings
- Optimisation of core design
- Change from CGO steel technologies (crystalline atomic structure) to amorphous cores (AMDT)(non-crystalline anisotropic atomic structure)
- Using superconducting technology (not yet feasible)

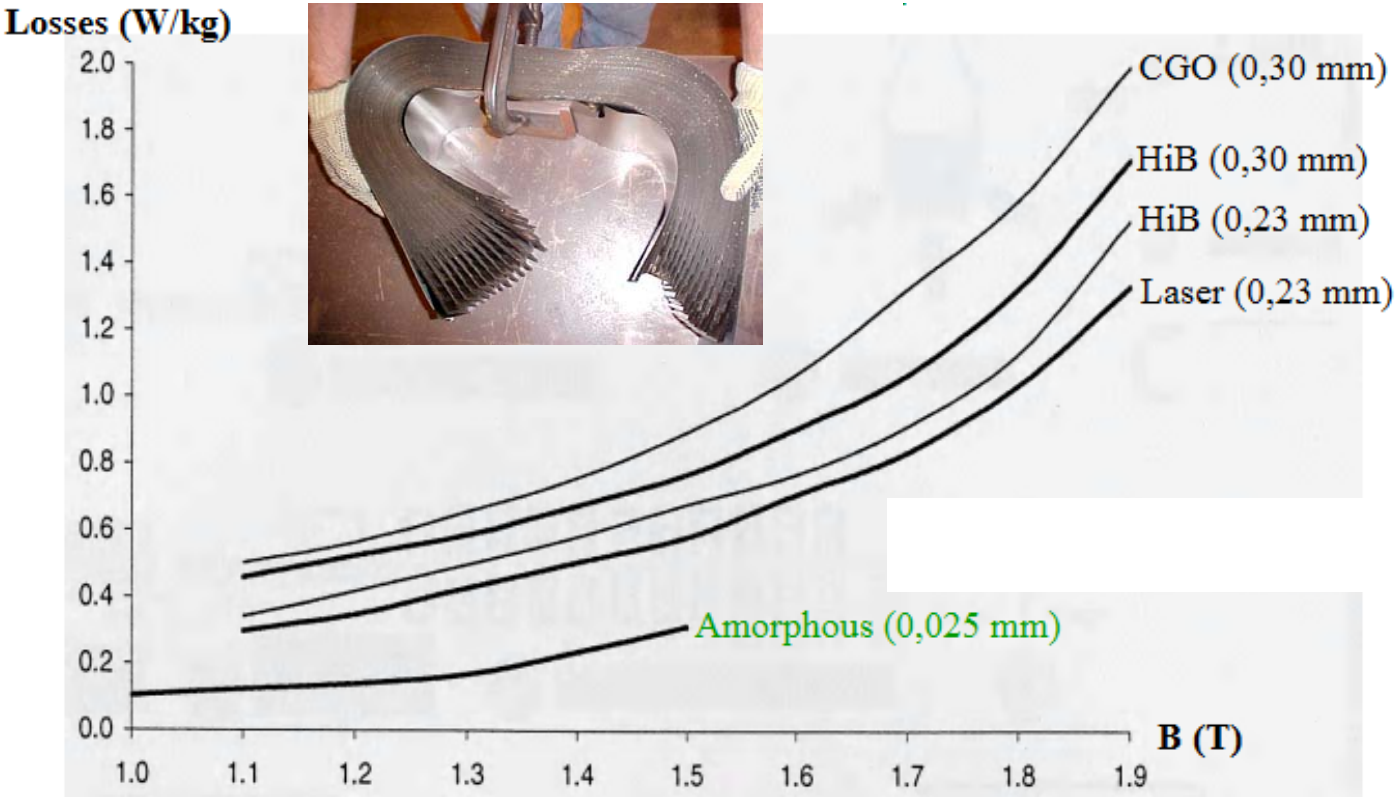
Evolution of CGO technology / core losses



CGO: Cold-rolled grain oriented silicon steels

HiB: High permeability grain oriented silicon steels

Evolution with amorphous metals
Amorphous core distribution transformers (AMDT)



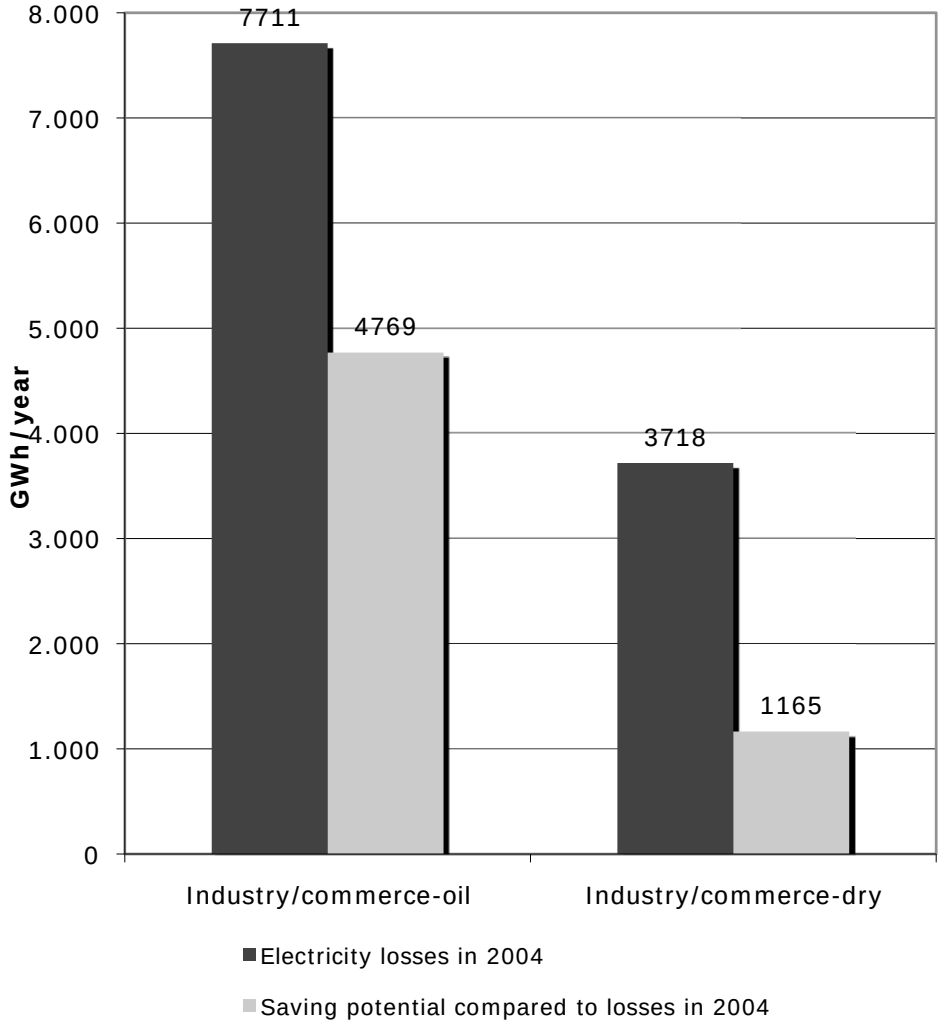
SEEDT

AMDT pilot project at Endesa

- 2007: economic and technical analysis with Asian manufacturers
- 2008: 20 units with 400 kVA purchased; energy efficiency class Ao for no-load losses according to EN 50.464-1
- Positive results so far:
  Each unit saves Endesa 5.5 MWh electricity per year
- Expansion planned

Source: Endesa
(Test of 10 amorphous distribution transformers in Mallorca in 2008)

Total technical potentials 2004



"Static" potential (BAT) in industry and commerce:

- Industry - oil: 61.8 %
- Industry - dry: 31.3 %
- **Total: 51.9% (6.1 TWh/year)**
- What part of potential can be realised by 2025?
  - ➢ 4 energy efficiency scenarios by SEEDT project

Energy efficiency potentials 2025 in EU-27 in industry and commerce [TWh/year]

Baseline: Frozen efficiency (2004 market losses); EU PRIMES development;

Policies and measures / energy savings starting in 2010

Transformer type	**Scenario 1** oil: AoBk / dry: HD 538	**Scenario 2** oil: AoAk / dry: HD538 LL ./. 10%, NLL ./. 10%	**Scenario 3** oil: Ao./.49% Bk+8% / dry: HD538 LL ./. 20%, NLL ./. 20%	**Scenario 4** oil: Ao./.49% Bk / dry: HD538 LL ./. 10% NLL ./. 40%
Liquid-filled	3.0	3.2	4.0	4.1
Dry-type	0.3	0.9	1.4	2.0

Economic impact of scenarios in 2025 in EU-27 in industry and commerce [net cost savings in Mio. Euro]

Baseline: Frozen efficiency (2004 market losses); EU PRIMES development;
Policies and measures / energy savings starting in 2010; 8% real discount rate

Transformer type	**Scenario 1** oil: AoBk / dry: HD 538	**Scenario 2** oil: AoAk / dry: HD538 LL ./. 10%, NLL ./. 10%	**Scenario 3** oil: Ao./.49% Bk+8% / dry: HD538 LL ./. 20%, NLL ./. 20%	**Scenario 4** oil: Ao./.49% Bk / dry: HD538 LL ./. 10% NLL ./. 40%
Liquid-filled	193	137	199	203
Dry-type	-15	9	-23	-86

Barriers and obstacles

Large industry	•Flexibility needs => low payback period; not core business
SME	•Lack of information and knowledge •Not core business •„Blind“ trust into external engineers carrying out the calculations
Engineering firms, ESCOs, energy consultants, planners	•Lack of information and knowledge •No incentive for better planning •No incentive to change routines: One-to-one replacement of old transformers following traditional, often oversized lay out of transformer design
Transformer manufacturers and their suppliers	•Risks of high investment in building up AMDT production line •Hardly any demand for AMDT in Europe yet •Volatile steel, aluminium and copper prices •Existing procurement routines and customer relations
General	•Lack of competences in economic calculation (load profile, etc.) •No AMDT production in Europe yet •Insufficient competition in amorphous metal / AMDT markets

Policy-mix proposed by SEEDT

Market actor	Regulation	Mandatory standard	Labelling	Incentives from obligations or certificate schemes	Other financial or fiscal incentives	Information, motivation, qualification	Inclusion into energy advice / audit programmes	Toolkit for buyers	Co-operative procurement	R&D, pilot / demonstration projects
Larger electricity distribution companies	**X**	(X)	(X)	(X) if not regulation	(X) if not regulation	(X)		(X)	(X)	**X**
Large industry		(X)	(X)		(X)	(X)		X	(X)	**X**
Smaller electricity distribution companies	**X**	(X)	**X**	(X) if not regulation	(X) if not regulation	**X**		X	X	X
Small and medium industry and commerce		**X**	**X**		X	**X**	**X**	X	(X)	X
Engineering firms, ESCOs, energy consultants, planners		**X**	**X**		(X)	**X**	**Service provider**	X	(X)	(X)
Transformer manufacturers (and their suppliers)		**Compliance required**						Can include it in marketing		**X**

bold = main focus within policy mix for this market actor
brackets = only partly relevant for this market actor, or just addressing small part within this target group

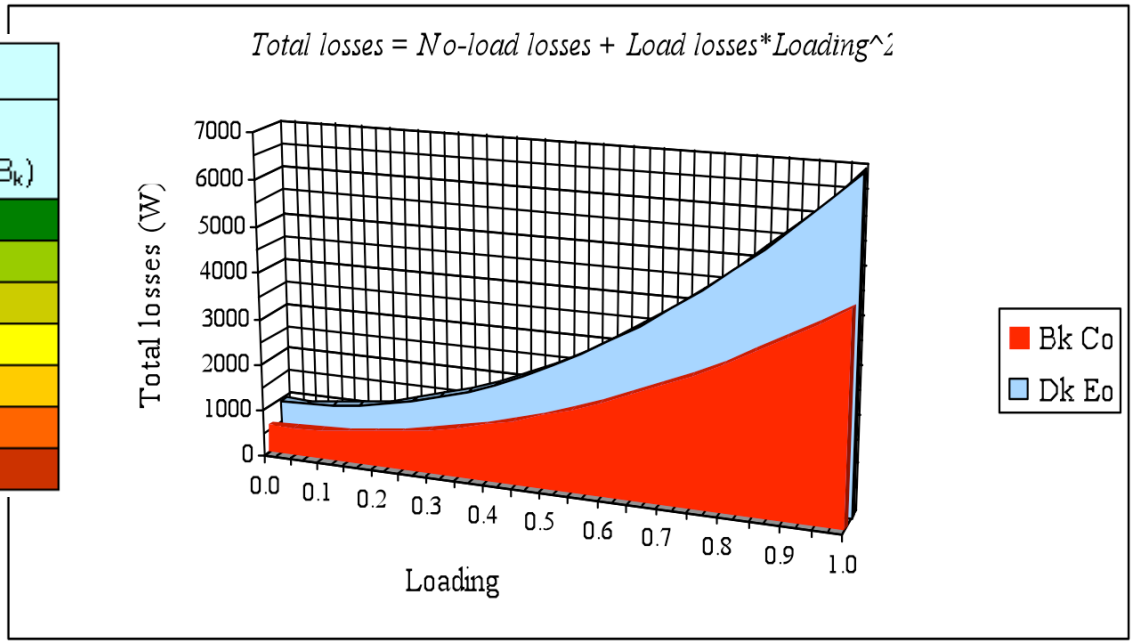
Labelling - One of three proposals

Labelling (A, B, C etc) through integration of losses from 0% to 100% loading

$$P_{int} = \int_0^1 P(L) \cdot dL \approx P_o + \frac{1}{3} \cdot P_k$$

The value of the integral classifies the DT

Labelling through integration	
LETTER	Integral of losses to reference $P_{int} / REF_{int} = (NLL+0.333 \cdot LL) / (C_o+0.333 \cdot B_k)$
A	Empty class today
B	$P_{int} / REF_{int} \leq 0.82$
C	$0.82 < P_{int} / REF_{int} \leq 0.92$
D	$0.92 < P_{int} / REF_{int} \leq 1.02$
E	$1.02 < P_{int} / REF_{int} \leq 1.12$
F	$1.12 < P_{int} / REF_{int} \leq 1.22$
G	$P_{int} / REF_{int} > 1.22$



C_o: Class of no load losses (EN 50464)

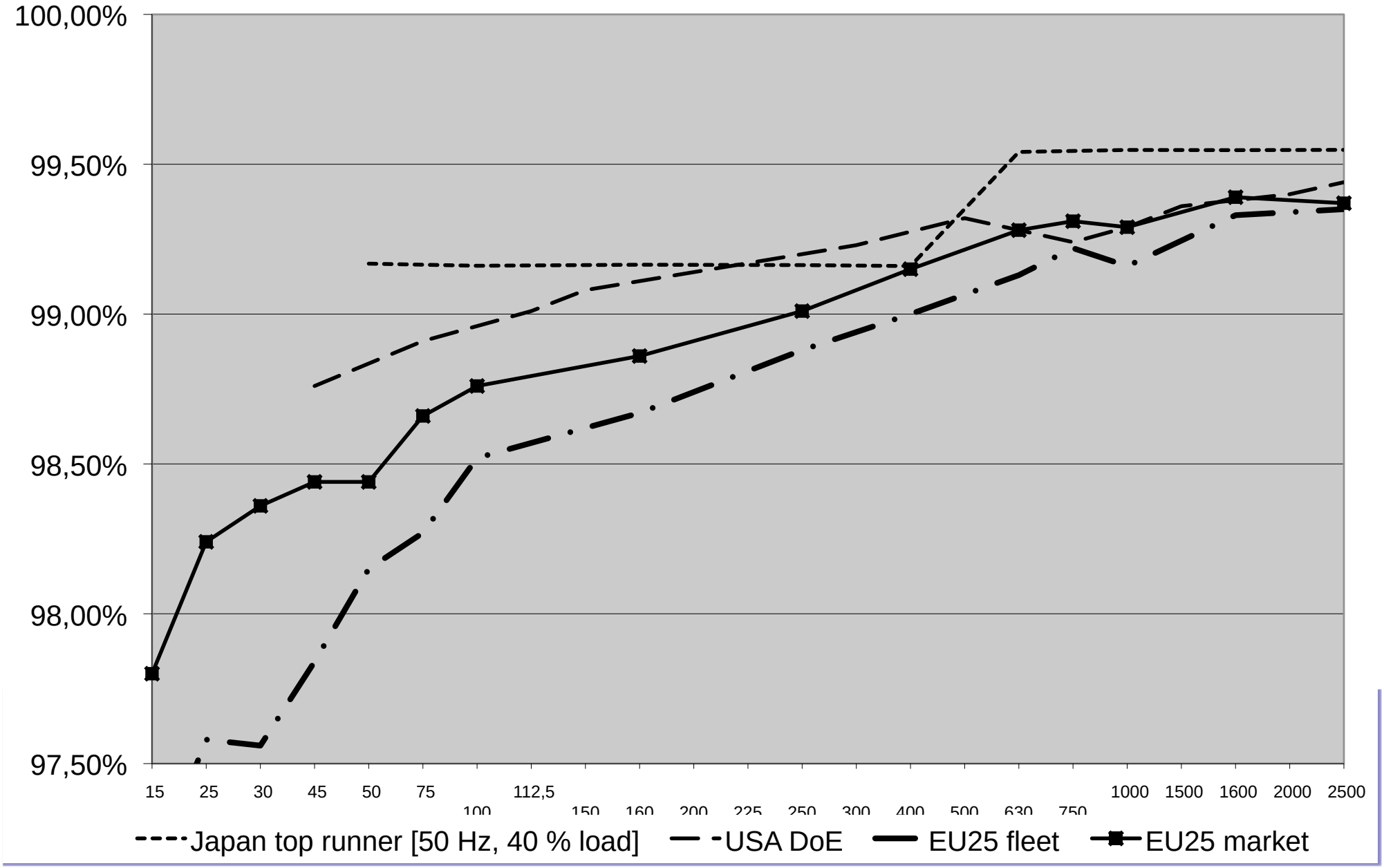
B_k: Class of load losses (EN 50464)

C_oB_k = CC' of HD 428

Mandatory efficiency standard

- European manufacturers are not interested in a voluntary agreement
- A mandatory EU-27 minimum efficiency standard will remove the worst DTs from the market [However: **only feasible** if regulation removes any disincentives for electricity distribution companies]
- It can be designed in one of the following ways:
  - maximum allowable no load and load losses (**SEEDT proposal: CoCk**), or
  - minimum efficiency at particular loading, or
  - just removing the worst labelling classes from the market

Will Europe catch up with the US and Japan?



Conclusions

- Electricity saving potentials of energy-efficient DTs in industry and commerce up to 6.1 TWh/year in 2025
- Calculations extremely sensitive to assumptions / price developments
- Economic benefit particularly with energy-efficient liquid-filled DTs
- Barriers and obstacles different between market actors
- Bundle of policy instruments needed on EU and national level
- Some chances for implementing policy instruments on EU level:
  - EU Action Plan on Energy Efficiency: Measures to reduce grid losses in 2008?
  - EuP Directive: On-going preparatory study
- Promotion of AMDT pilot projects can increase competition in the market

Intelligent Energy Europe

Thank you

Have you already visited the project website?

http://seedt.ntua.gr