

Evaluation and Monitoring for the EU Directive
on Energy End-Use Efficiency and Energy Services

Setting up a bottom-up method: Variable Speed Drives



ISR - Universidade de Coimbra



Plan of the presentation

- **First phase: analysing the available material**
 - Examples of available data
 - Example of calculation method
- **Second phase: first proposal**
 - Possible Three levels for the "technical" baseline (measure specific)
 - Main parameters for the unitary energy savings
 - Three levels for the energy consumption data, normalisation factors, conversion factor (measure specific)
 - Proposed requirements for the accounting methods
 - Insights for double counting, technical interactions and multiplier effect

First phase: analysing the available material

- **Available material:**
- Past SAVE projects:
 - “VSDs for Electric Motor Systems”
 - “Improving the Penetration of Energy-Efficient Motors and Drives”
 - Motor Challenge Programme
- Others: Portugal (PPEC), USA (FEMP and others), South Africa
- **Current accounting in the obligation systems:** White Certificates Italy and Flanders
- **Regulations and standards**
 - Ecodesign Directive (motors, motors + VSDs)
 - Norm CEI EN 61800-2 and 4: Electrical drives with variable speed
 - Motor Labelling (Eff1, Eff2, Eff3)

First phase: analysing the available material

Organising the available information:

- **defining the measure**
- listing the **available data**
- reviewing the **evaluation methods used**
- **technical details** (basis for the unitary energy savings)
- details about the **market analysis** (basis for the number of actions)
- **differences between Member-States** (objective of harmonisation)

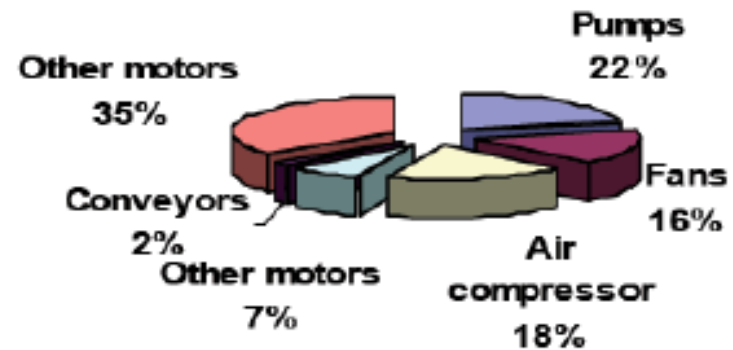
→ [following the process proposed in EMEEES task 4.1](#)

First phase: analysing the available material

Example of Available Data:

- Characterisation of the market for VSDs:
 - Motor consumption by power range

Motor electricity consumption: Industrial sector

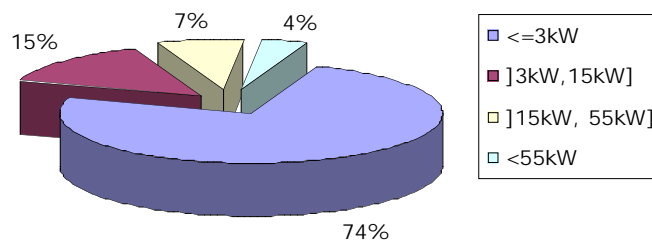


<i>Motor electricity consumption forecast by 2015 (TWh pa)</i>		
<i>Power Ranges (kW)</i>	<i>Industrial sector</i>	<i>Tertiary sector</i>
[0.75 4]	46.9	66.2
]4 10]	55.8	58.8
]10 30]	95.0	53.6
]30 70]	143.9	12.7
]70 130]	83.6	10.7
]130 500]	166.3	6.3
Total	597.8	222.4

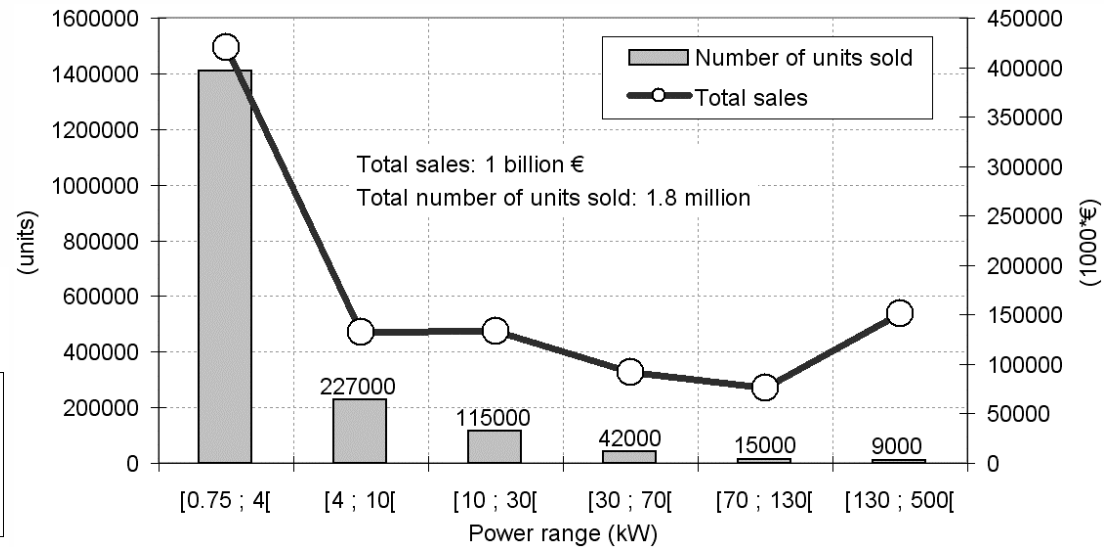
First phase: analysing the available material

Available Data:

- Characterisation of the market for VSDs:
 - Number of units sold (before and after EEI measure)
 - Average retail prices
 - Average installation costs
 - Market Segmentation



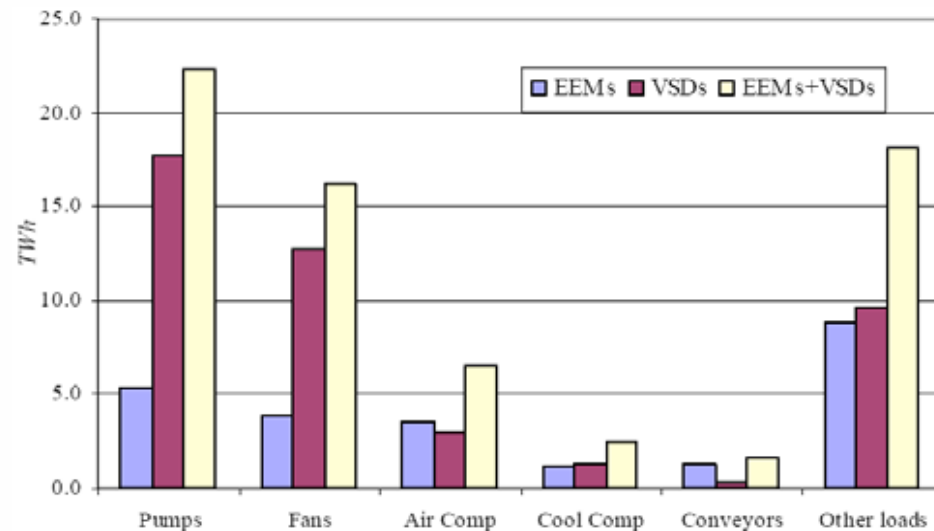
Percentage of VSDs sold in Portugal in 2003, by power range (Shneider)



Number of units sold in the EU and sales value per power range, in 2002, in EU15

First phase: analysing the available material

o Economic potential savings studies (by type of load and sector)



	Av. Savings
pumps	35%
fans	35%
air compressors	15%
cool compressors	15%
conveyors	15%
other motors	15%

SAVE II –Industrial sector

- o **Different types of data** (technical, market) **and of sources** (statistics, modelling, monitoring, engineering estimates)
- o **Average efficiency gain** for EU15: 20-60% (depending on end use and load)

First phase: analysing the available material

Example of calculation method

Step 1 → Defining the **average unitary energy savings**

- Italian White Certificates (1 of 2): **standard approach** - Motors < 22kW

Energy saving obtained for each pump that has an inverter:

$$RL = RSL * P \text{ (toe/year/pump)}$$

Where **RSL** is obtained from the following chart as a function of the nominal power of the pump (in kW).

Type of activity	Static prevalence (% of nominal prevalence)			
	0	20	40	60
Industrial 1 shift of work	0,09783	0,07487	0,05191	0,02895
Industrial 2 shifts of work	0,19565	0,14974	0,10382	0,05791
Industrial 3 shifts of work	0,37565	0,28750	0,19934	0,11118
Industrial seasonal	0,10565	0,08086	0,05606	0,03127

First phase: analysing the available material

- Italian White Certificates (2 of 2): **engineering approach** (Motors >22kW)

$$Savings = 0.22 \times 10^{-3} \times \left(\sum_{i=1}^N P_{V,i} NH_i - \sum_{i=1}^N P_{I,i} NH_i \right)$$

- PV,i - electrical power absorbed by the motor in the case of Throttle Control
- PI,i - electrical power absorbed by the motor in the case of VSD
- NH_i – Number of working hours
- Conversion factor 1kWh = 0.22 X 10⁻³ toe

First phase: analysing the available material

Example of calculation method:

- **step 2** → accounting for the number of VSDs sold and motors consumption by end-use
 - Italian White Certificates: VSDs sold within the obligation system
- **step 3** → **gross-to-net correction factors**
 - **Double counting**: not considered
 - **Multiplier effect**: requiring market analysis (survey data, sales data) + past experiences
 - **Free-rider effect**: market surveys show that VSDs are mostly used for process control and to ensure the correct MTBF, in lower power ranges[0,75;4[kW
 - **Spill over**: not considered in the available material

Suggested basic formula to calculate savings

Example of calculation method: 1st approach – Case Specific

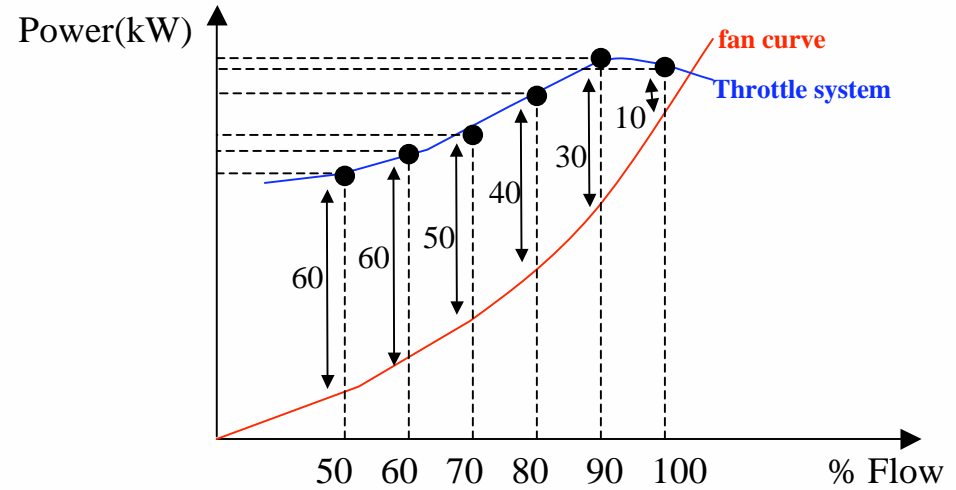
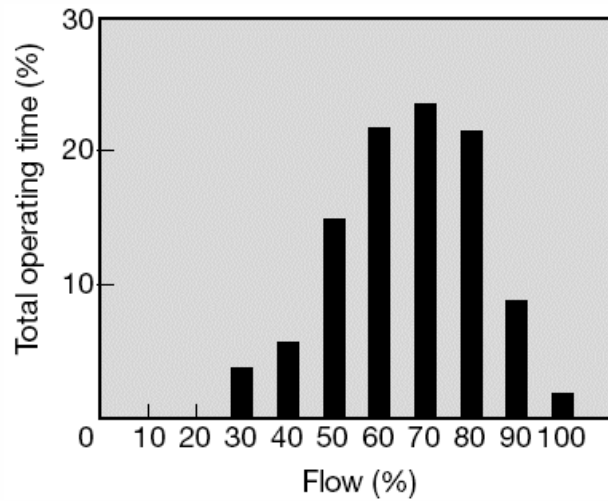
$$Savings = P_{elect} \times \left[\left(\sum_{i=1}^n (H_i(\text{hours}) \times Load_{T_i}) \right) - \left(\sum_{j=1}^n (H_j(\text{hours}) \times Load_{V_j}) \right) \right]$$

T – Throttle
V - VSD

Default Load Values (Power/Flow)						
	100%	80%	50%			
Throttle	1	0,7	0,5			
VSD	1	0,55	0,15			
Motor Power	Number of working Hours			Throttle	VSD	Savings
kW	100%	80%	50%	kWh	kWh	kWh
0,0	0,0	0,0	0,0	0,0	0,0	0,0

$\left\{ \begin{array}{l} Load_{T,V,i,j} - \text{function of system characteristic (Power vs. \% Flow)} \\ P_{elect} = \frac{P_{mec}}{\eta} \end{array} \right.$

Example of load diagram



Suggested basic formula to calculate savings

Example of calculation method: 2nd approach – Evaluation with pre-defined standard values

Defining the **average unitary energy savings, by type of load**

Average default savings by **power ranges**:

$$\left(\frac{P_{mec}}{\eta} \times Av.LoadFactor \times Av.OperatingHours \right) \times Av.Savings$$

	Av. Savings
pumps	35%
fans	35%
air compressors	15%
cool compressors	15%
conveyors	15%
other motors	15%

Second phase: first proposal

Main parameters for the unitary energy savings:

“internal” factors affecting the average motor consumption:

- **Load variation**
- **Duty Cycle – operating hours per year**
- **Type of control**
- **Type of Load**
- **Level of energy efficiency of the motor**

+ factors affecting the average efficiency gains (temperature, thermal class and insulation, voltage and coupling, ...)

Second phase: first proposal

Three levels for the energy consumption data: standard baseline

Level 1	Default conservative value for average load factor and operating hours value based on the available data from EU studies and among Member-States, for motors with throttle control
Level 2	national studies about average load factor and operating hours value (not available for all MS).
Level 3	Average value taking into account participants' data (e.g. billing data, working hours, load types, motor efficiency, ..)

Second phase: first proposal

Calculation parameters for each main type of application:

- Type of end-use: pumps, fan, compressors, conveyors, lifts
- Load variation
- Operating hours: national studies (level 2) or monitoring data (level 3)
- Load Factor
- Motor Power ranges: national studies (level 2)
- Typical saving lifetime (level1): 15 years? (CWA 27: default value 8 years)

Second phase: first proposal

Double counting (component and system effects):

Technical interactions:

- Possible interactions with measures improving motor efficiency
- in that case, the efficiency gain should be applied to the improved motor consumption
- difficulties: monitoring the cases where it occurs → is it worth?

→ *Recommended evaluation method: **Surveys***

Free rider Effect:

- VSDs mostly used for process control and to improve MTBF, mainly in lower power ranges[0,75;4[kW

→ *Recommended evaluation: **Surveys of participants and non participants***

Second phase: first proposal

Multiplier effect:

- Multiplier savings in VSDs happened in the past (eg.: consequence of implementation by PG&E, SCE or Niagara Mohawk).
- defining requirements for market analysis → common for all methods related to the promotion of an efficient product?
- **How long should the multiplier savings be accounted for?**
 - at least equipment's lifetime
 - <-> new multiplier effects: analysis of market/diffusion indicators needed
- **Possible market-changing regulations:**
 - Eco Design Directive
 - Norm IEC 61800-2 and IEC 61800-4

Conclusions

- Several available materials:
 - French (if already available) and Italian White Certificates, Portuguese Promotion Plan for Energy Efficiency, US Federal Energy Management Programme will be the references; Flanders has method too
- Definition of different power ranges, based on European and national MS data (statistics, previous surveys/ studies, ...)
- Definition and quantification of net-to-gross correction factors through surveys
- Ex-post audits represent a serious budget burden ! Should it be done sporadically to a small random participant sample?