4. Bottom up – method 13 B: Variable Speed Drives

5.0 Recalling Elements of Calculation:

Four steps for calculation

- **step 1**: **unitary gross annual energy savings**
  (per end-use action)
  (**+**) no. of participants or units
- **step 2**: **total gross annual energy savings**
  (of a facilitating measure)
  (**+**) double counting, multiplier effect, free rider effect
- **step 3**: **total ESD annual energy savings**
  (of packages of EEI measures)
  (**+**) timing and lifeline of end-use action within ESD period and performance degradation
- **step 4**: **total ESD energy savings for year "i"** **(i=2010 or 2016)**

5.2 Recalling Elements of Calculation: Three levels of evaluation efforts

	Data scale	Main data sources	Data processing and documenting
Level **1**	**European default values**	**existing/available** European regulation, studies and statistics	**security factor** according to the level of **reliability** of the default value
Level **2**	**National** representative **values**	**up-to-date** national statistics, surveys, samples, registries	requirements = **minimum set of information and justifications** to be reported
Level **3**	**Program- or Participant-specific**	**specific** monitoring systems, registries, surveys, measurements	requirements to report on the specific data and justifications **in detail** (standard report at least available)

➔ an evaluation method may combine different levels of efforts, as several parameters are needed in the calculations

4.1 Harmonised bottom-up evaluation methods
Method 13B: Variable Speed Drives

- a method dealing with a type of **end-use action**
- the **unit** is a Variable Speed Drive (VSD) installed
- VSDs are electronic devices for energy-efficient control of electric motors in industry and large buildings
- If the load driven by the motor is fluctuating (as often with, e.g., pumps, fans, compressors, elevators), large energy savings can be made

(method developed by ISR – University of Coimbra, Portugal)

4.1 Variable Speed Drives

- **Step 1.1: Basic calculation formula for the <u>unitary</u> savings**

  Annual energy savings of one participant = the participant's energy consumption before installing a VSD – the participant's energy consumption after installing a VSD

- **Step 1.2: General baseline**

→ The baseline to be considered is EFF2 motors with throttle control

4.1 Variable Speed Drives

- **Step 1.3: Normalisation factors**

→ Annual Operating hours and Load factors are both an input parameter for the calculation of energy savings, and a potential normalization factor for energy use of motors with VSDs.

4.1 Variable Speed Drives

- **Step 1.4: Specifying the calculation method and its three related levels: two options depending on motor size**

A) [savings] are estimated **for motors smaller than 22kW** using a default % of savings in **level 1** (EU default values for parameters) and **level 2** (national average values for parameters from sample surveys), or a **measure-specific level 3** (average values for parameters from surveys of a sample of participants to the facilitating measure being evaluated).

$$\text{unitary gross annual energy savings per unit} = \left(\frac{P_{mec}}{\eta} * Av.LoadFactor * Av.OperatngHours \right) * Av.DefaultSavings$$

4.1 Variable Speed Drives

- **Step 1.4: Specifying the calculation method and its three related levels**

B) [savings] are estimated **for motors larger than 22kW with a case-specific level 3 method of evaluation:**
(Method used for White Certificates in **Italy** for motors ≥22kW)

$$\text{unitary gross annual energy savings per unit} = \sum_i \left(\left(P_T^i - P_{VSD}^i \right) * h^i \right)$$

With:

P_T^i – Electrical Power, with throttle control

P_{VSD}^i – Electrical Power, with VSD

h^i – Number of working hours for each power level

i – Load profile index (Number of hours for each load range)

4.1 Variable Speed Drives

- **Step 1.4: Specifying the calculation method and its three related levels: motors < 22kW)**

	Level 1	Level 2	Level 3
A)	unitary gross annual energy savings per unit = $\left(\frac{P_{mec}}{\eta} * Av.LoadFactor * Av.OperatngHours\right) * Av.DefaultSavings$		
	- EU default value for η, Av.LoadFac-tor, Av.Operatng Hours, % of savings (Av. DefaultSavings)	- national averages for η, Av.LoadFac-tor, Av.Operatng Hours, % of savings (Av. DefaultSavings)	- programme- or service-specific averages for η, Av.LoadFactor, Av.Operatng Hours, % of savings (Av. DefaultSavings)

4.1 Variable Speed Drives

- **Step 1.4: Specifying the calculation method and its three related levels: motors >= 22kW)**

	Level 1	Level 2	Level 3
C)	unitary gross annual energy savings per unit = $\sum_i \left(\left(P_T^i - P_{VSD}^i \right) * h^i \right)$		
	- not applicable	- not applicable	**- unit-specific data**

4.1 Variable Speed Drives

- **Indicative default value** for the unitary savings **(1)**

→ default values for *Av.LoadFactor, Av.Operatng Hours,* **option A (< 22 kW), Level 1:**

Power ranges	Type of Applications	Industry		Tertiary	
		Hours (h)	Load factor	Hours (h)	Load factor
[0,75;4[	Pumps	3861,03	0,55	3800	0,55
[4;10[		4501,94	0,58	3050	0,60
[10;22[		5040,47	0,59	3000	0,60
[0,75;4[	Fans	4910,47	0,53	2250	0,60
[4;10[		4137,76	0,56	2500	0,65
[10;22[		5210,64	0,59	2500	0,65

4.1 Variable Speed Drives

- **Indicative default value** for the unitary savings, < 22 kW **(2)**

[0,75;4[	Air Compressor	2177,99	0,63	1030	0,40
[4;10[		4057,72	0,60	1000	0,45
[10;22[		4625,99	0,68	980	0,45
[0,75;4[	Conveyors	3060,75	0,42	621	0,61
[4;10[		2787,90	0,41	916	0,53
[10;22[		3908,61	0,51	725	0,49
[0,75;4[	Cooling Compressors	5051,90	0,60		
[4;10[		1890,63	0,65		
[10;22[		5066,59	0,70		
[0,75;4[	Refrigeration			4200	0,70
[4;10[				4170	0,70
[10;22[				4050	0,75
[0,75;4[	Others	3086,64	0,34	500	0,30
[4;10[		2859,49	0,39	530	0,30
[10;22[		2299,44	0,45	570	0,30

4.1 Variable Speed Drives

- **Indicative default value** for the *Av. DefaultSavings* to calculate unitary savings **(3) with option A (< 22kW), level 1**

End-Use	Average VSD Savings (%)
Pumps	28
Fans	28
Air Compressors	12
Cooling compressors	12
Conveyors	12
Other Motors	12

4.1 Variable Speed Drives

- **Main data needed for Option A**

	Level 1	Level 2 and 3
A)	- Mechanical power of motor for each VSD applied - Type of application (pump, fan, compressor, conveyor, other) for each VSD -Number of VSD sold	- Mechanical power of motor for each VSD applied - Average percentage of energy savings from VSDs (per end-use and possibly power range) -(Average) Number of working hours (per end-use and power range) -(Average) Load Factor (per end-use and power range) -Mechanical power -Type of application (pump, fan, compressor, conveyor, other) -Number of VSD sold

4.1 Variable Speed Drives

- **Main data needed for option C)**

	Level 1 and 2	Level 3
C)	- not applicable	- Motor electricity consumption at different typical loads -Flow Data Requirements at the same loads - annual hours of use at these loads

4.1 Variable Speed Drives

- **Step 2.1: calculation formula for the <u>total gross</u> annual energy savings**

  - unit = each installed VSD, both for option A and B.

$$Total\_gross\_annual\_energy\_savings = \sum_{i}^{n} [energy\_savings\_of\_VSD\_i]$$

4.1 Variable Speed Drives

- **Step 2.2: Requirements and methods for accounting for the number of unitary actions**

→ Methods proposed for monitoring the number of actions (always LEVEL 3):

Direct accounting methods are particularly appropriate with the use of: - Financial Tools (rebates, low interest rates, targeted taxation, e.g., tax rebates or faster depreciation rates) - Energy Audits - Energy Performance Contracting - White Certificates Schemes	**Examples of methods** - Collection of accounting documents (e.g. invoices, vouchers) - registry/database to collect details about participants and end-use actions proposed/taken
Indirect accounting methods are particularly appropriate with - Minimum Energy Performance Standards - Lifecycle costing campaigns	**Examples of methods** - surveys among the target groups to assess the portion/number of implemented end-use actions - surveys among the whole population targeted to assess compliance

→ Finally, ex-post verification for a sample of participants should be done: monitoring of implementation and of energy consumption to ensure that end-use (EEI) actions are actually in place and operational, as specified initially.

4.1 Variable Speed Drives

- **Step 3.1: formula for the <u>total ESD</u> savings**

total net annual energy savings
= total gross annual energy savings of all VSDs (from step 2.1)
** (1 - free-rider coefficient + multiplier coefficient)*
** double-counting factor*

→ Simplified formula, if total annual energy savings are below 40 million kWh/year, or if there is evidence that both the multiplier and the free-rider effects will be small:

total net annual energy savings
= total gross annual energy savings of all VSDs (from step 2.1)
** double-counting factor*

Possible range of coefficients:
Free-rider: share [0, 1]
Multiplier coefficient: >=0
Double Counting: factor [0, 1]

4.1 Variable Speed Drives

- **Step 3.2: double counting**

	Energy Audits	Energy Performance Contracting	White Certificates Schemes	Energy Taxation	Subsidy schemes	Risk of Overlap
Installation of Variable Speed Drives	X	X	X	X	X	X
Energy Efficient Motors	X	X	X	X	X	X
Improved Maintenance	X				X	
….						

- **Step 3.3: technical interactions**

	VSDs	EEMs
VSDs		+
EEMs	+	

4.1 Variable Speed Drives

Step 3.4: multiplier effect

- Ex-Ante calculations previewing the multiplier effect should be performed by the evaluator, as soon as the MS reveals its National Energy Efficiency Action Plan (NEEAP).

Step 3.5: free-rider effect

1st approach	Stock/Market modelling: Level 2 - Baseline based on National Statistics Level 3 – Measure specific Data
2nd approach	Definition of Net-to-Gross Ratios (NTGR) (implies surveys to participants or discrete choice modelling) Level 2 - National NTGR Level 3 – Measure Specific NTGR
3rd approach	Progressive Approach

4.1 Variable Speed Drives

Years after start of facilitating measure implementation	Accounting Method
[0,3[	General Default NTGR ratios **or** Stock/Market Modelling. MS can propose methods to define MS values of NTGR, taking into account that these methods should be applicable for all MS (it is up to the Commission – in a mid-term evaluation - to decide whether the methods are relevant or not).
>3	According to experience gained for all MS, new proposal not requiring the estimation of free-riders but the use of a default NTGR

- **Step 4: savings lifetime**

VSD's	Default values: 8 **years** (value from CWA-27).

4.1 Variable Speed Drives

Quality assurance / uncertainties

for option A we estimate:

For efficiency : +/- 1 to 2 %

For load factor and operating hours: +/- 10 to 15%

For default savings of VSD: +/- 10 %

for option B we propose to require:

Measurement Equipment	Measurement Tolerances
4-Channel power data loggers , True RMS power analyzer, Flow meter	Data loggers: +/- 1% Power analyzer: +/- 1% Flow meter: +/- 2%