EUROPEAN ASSOCIATION OF PUMP MANUFACTURERS
ASSOCIATION EUROPÉENNE DES CONSTRUCTEURS DE POMPES
EUROPÄISCHE VEREINIGUNG DER PUMPENHERSTELLER

EXTENDED PRODUCT APPROACH FOR PUMPS

A Europump Guide

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Draft version

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This working document for a future Europump guide on the Extended Product Approach is prepared by a subcommittee of the Europump Standards Commission. It has not been presented or discussed in the Europump Standards Commission or the joint working group for EuP/ErP and currently does not reflect the position of Europump.

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Foreword

This working document is prepared by a subcommittee of the Europump Standards Commission which consists of the following members:

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The working document will serve as a communication tool towards the European Commission during the legal process concerning the ecodesign requirements based on the extended product approach (EPA) for pumps. At a later stage this working document will be elaborated into a Europump guide, as an aid for pump manufacturers and users to ensure compliance with the future regulation on the extended product approach (EPA) for pumps.

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1 Introduction

Europump's answer to the ecodesign directive for pumps is based on three pillars as shown in Figure 1. The Product Approach focuses on the efficiency of the pump alone. The Extended Product Approach is focused on the extended product i.e. pump, motor and VSD (when applied). The System Approach focuses on optimising the pumping system. The purpose of this guide is to describe the methodology for future implementing measures (i.e labelling, legislation etc.) for extended pump products (EPs).

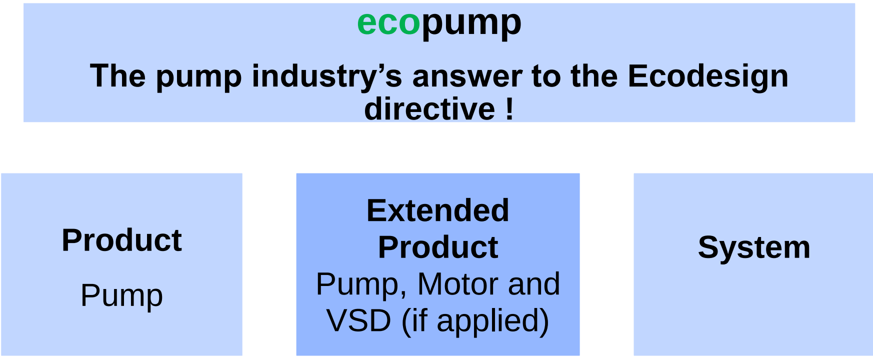


Figure 1 Ecopump initiative by Europump

Implementing measures based on a Product Approach take only the efficiency of the product into account, whereas the Extended Product Approach via the load profile and control curve also takes the reductions in energy consumption due to pump operation into account.

1.1 Pumps in scope

The Extended Product Approach (EPA) is implemented for circulators and has formed the basis for the ecodesign requirement for these products since January 1, 2013 [1], [2].

Figure 2 shows the road map for ecodesign requirements for pumps.

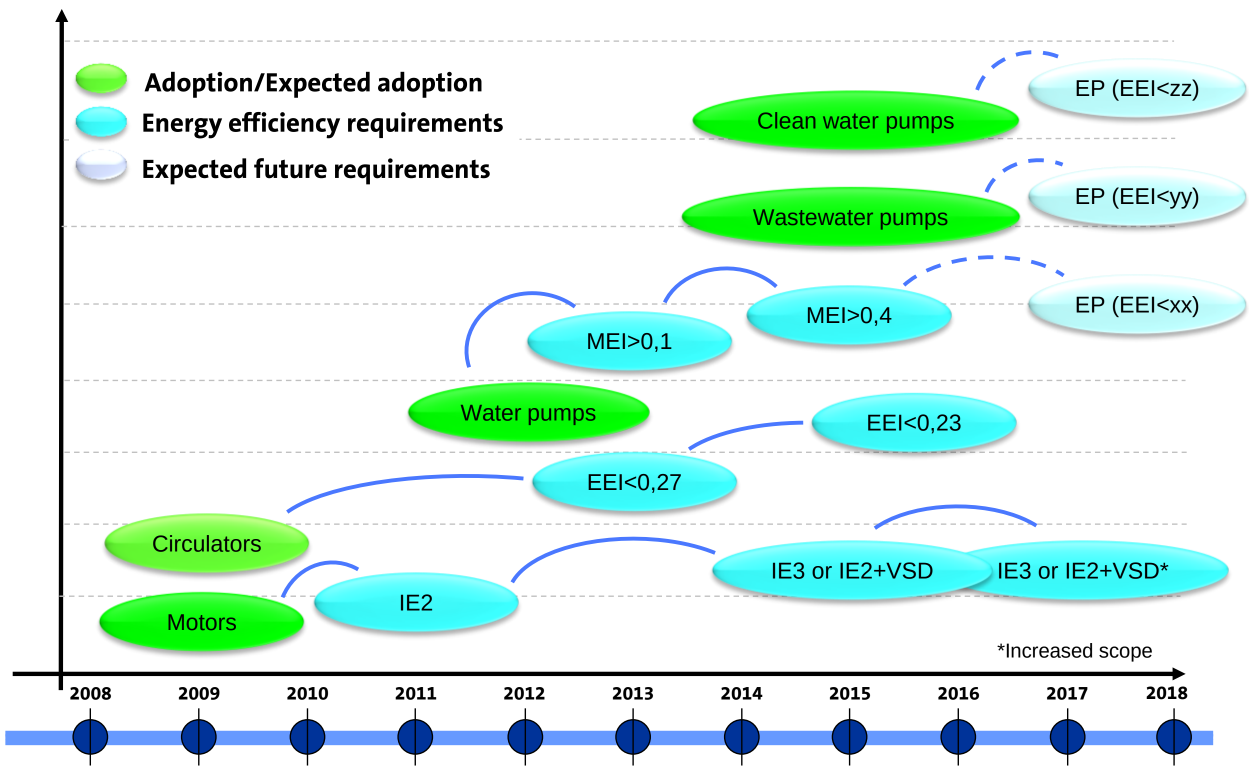


Figure 2 Road map for energy efficiency regulation on pumps in EU

Ecodesign requirements based on extended products (EPs) are expected to be introduced during the next 3 years and the requirements will be based on an Energy Efficiency Index (EEI) as for circulators. The following pump products are expected to be targeted:

- Water pumps as defined [3]
- Booster systems (directly or indirectly)
- Wastewater pumps as defined in [4]
- Clean water pumps as defined in [5]

At the moment the conclusions in this paper have only been verified for clean water single pump units and pressure boosting systems as a subset of multistage vertical clean water pumps as defined in Commission regulation 547/2012 (EU) [3]. Pumps in other applications (e. g. like [4] or [5]) may consider different Flow-time profiles and Reference Control Curves. These are subject of further/ later investigations.

1.2 Energy savings

The main driver for the Extended Product Approach is the huge energy saving potential. Europump estimates that a marked transformation based on the EPA for water pumps in the scope of Commission Regulation 547/2012 alone will lead to energy savings of 35 TWh per year, which is approximately ten times greater than the saving in 2020 achieved by the current regulation for water pumps.

2 Extended Product Approach for pumps

It is important to distinguish between the *Extended Product Approach (EPA)* and the *Extended Product (EP)*.

- **Extended Product Approach (EPA)**: a methodology to calculate the Energy Efficiency Index (EEI) of an Extended Product (EP), which incorporates load profiles and control method.

- **Extended Product (EP)**: consists of physical components

The EPA is a methodology or procedure which can be used to qualify an extended product for a certain efficiency level, whereas the EP is the actual product. This is shown graphically in Figure 3.

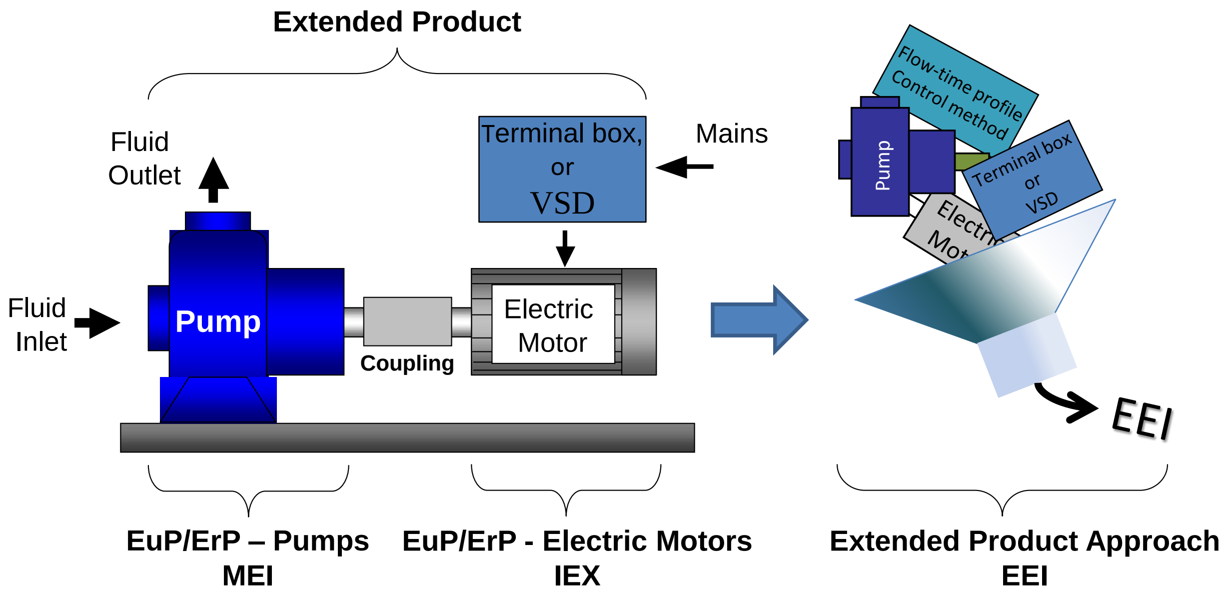


Figure 3 Definition of Extended Product Approach

Extended pump products are placed on the market as integrated units i.e. a pump, a motor with or without VSD which is supplied by one manufacturer as a complete unit. They are also placed on the market as separated units i.e. where the pump, motor and VSD are separate products supplied by one or more manufacturers. The EPA must be able to handle both integrated and separated extended pump products.

This leads to the following general definition for an extended pump product

> *Extended pump product means a pump driven by an electric motor with or without a variable speed drive (VSD)*

This definition is valid for all extended pump products in the scope, including circulators. The speed control is based on a system feedback which can come from sensors in the system or in the pump or from sensorless feedback transmitted by the motor.

3 Flow-time profiles and reference control curves

Extended pump products are used in a variety of applications. In the EPA methodology all applications are divided into

- Constant flow systems
- Variable flow systems

For both type of systems typical, standardized flow-time profiles and reference control curves are defined and used to calculate the corresponding EEI. The flow-time profile describes the percentage of time a certain flow is needed in the system. The reference control curve is a standardized control curve, which describes the desired head at the flows defined in the flow–time profile.

The same flow-time profile and reference control curve applies to both fixed speed pumps and variable speed pumps. Both types of pumps can operate according to the flow-time profile, but fixed speed pumps are not in all cases capable of operating at the head determined by the reference control curve, as the head of a fixed speed pump is determined by the pump's fixed-speed characteristic.

The typical, standardized flow-time-profiles and control curves neither do represent nor cover all the different demands in pumping applications. They only are used as basis for a manageable Energy Efficiency classification of the pump units in scope.

3.1 Constant flow systems

Constant flow systems can be both open loop and closed loop systems. A typical open loop constant flow system is in an application where the purpose of the pump is to move liquid from one reservoir to another. A typical example of a constant flow closed loop system is in application where the purpose of the pump is to transport energy inside a systems i.e. from an energy supply source ton an energy sink.

3.1.1 Reference control curve for constant flow systems

In a constant flow *open loop* system the pump must overcome a certain nearly constant static pressure. In a constant flow *closed loop* system the pump must overcome a certain nearly constant friction loss. In both systems variable speed makes no sense and the reference control curve therefore coincide wioth the pump curve as shown in Figure 4 (green line).

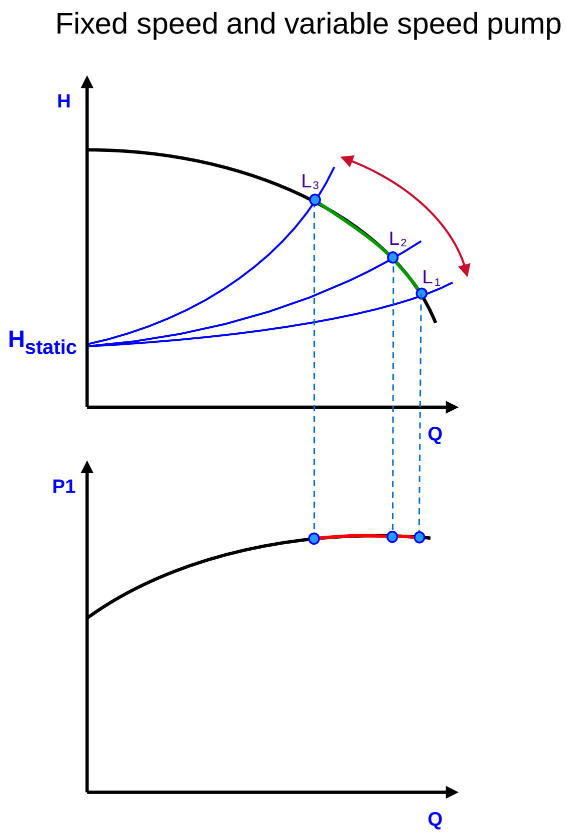
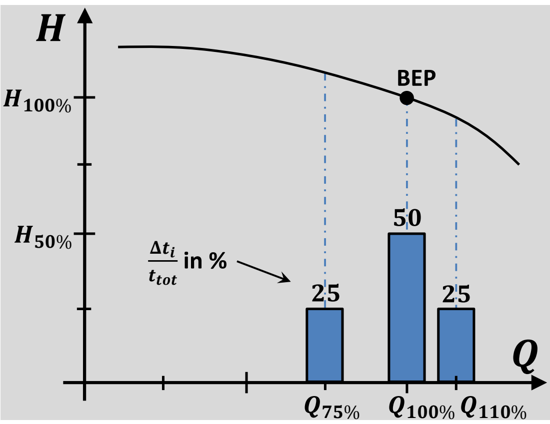


Figure 4 Reference control curve for constant flow systems (open and closed loop)

3.1.2 Flow-time profile for constant flow systems

In a real system the flow is very seldom constant. Even in a very simple pump system where the pump is used to move liquid from one reservoir to another, the duty point will vary due to the level of the reservoirs and will not operate all time at the best efficiency point even if it is designed to do that. The flow-time profile in a *constant flow* system is in the EPA methodology per definition defined as shown in Figure 5.



	Flow [%]	Time [%]
L_1	110	25
L_2	100	50
L_3	75	25

Figure 5 Flow-time profile for constant flow systems (open and closed loop)

The flow varies between 75% to 110% of the flow at BEP. These are the same load points as used for MEI calculation of water pumps, where a flow-time profile has been added. The flow-time profile is also per definition set to 50% at BEP point and over load and part load operation is equally distributed with 25% in each duty point.

The EEI calculation of all pumps (fixed speed and variable speed) used in constant flow systems (open loop and closed loop) will be calculated according to the flow-time profile shown in Figure 5 and reference control curve shown in Figure 4.

3.2 Variable flow system

Variable flow systems can also be open loop and closed loop systems. A typical closed loop system is a hydronic distribution system of a heating and/or air conditioning system (HVAC-system). The purpose of the pump is to distribute energy from the energy supply (boiler, chiller etc.) to the emission systems (radiator, coils, air handling units etc.) by circulating a pumped media. The pump must deliver enough head to overcome friction losses in the system and satisfy the requirement for actuators (valves etc.) which typically needs some extra pressure to operate correctly. In open loop variable flow systems the pump must in addition to the friction losses overcome a certain static pressure due to height.

3.2.1 Reference control curve for variable flow systems

At part load the pump head can be reduced due to reduction in friction losses in the system. An energy efficient pump control must take that into account. For that reason a reference control curve for variable flow systems in building services applications is defined as a linear curve defined by ($Q_{100\%}$, $H_{100\%}$) and ($Q_{0\%}$, $H_{50\%}$). Figure 6 shows the reference control curve as defined for these systems (green line).

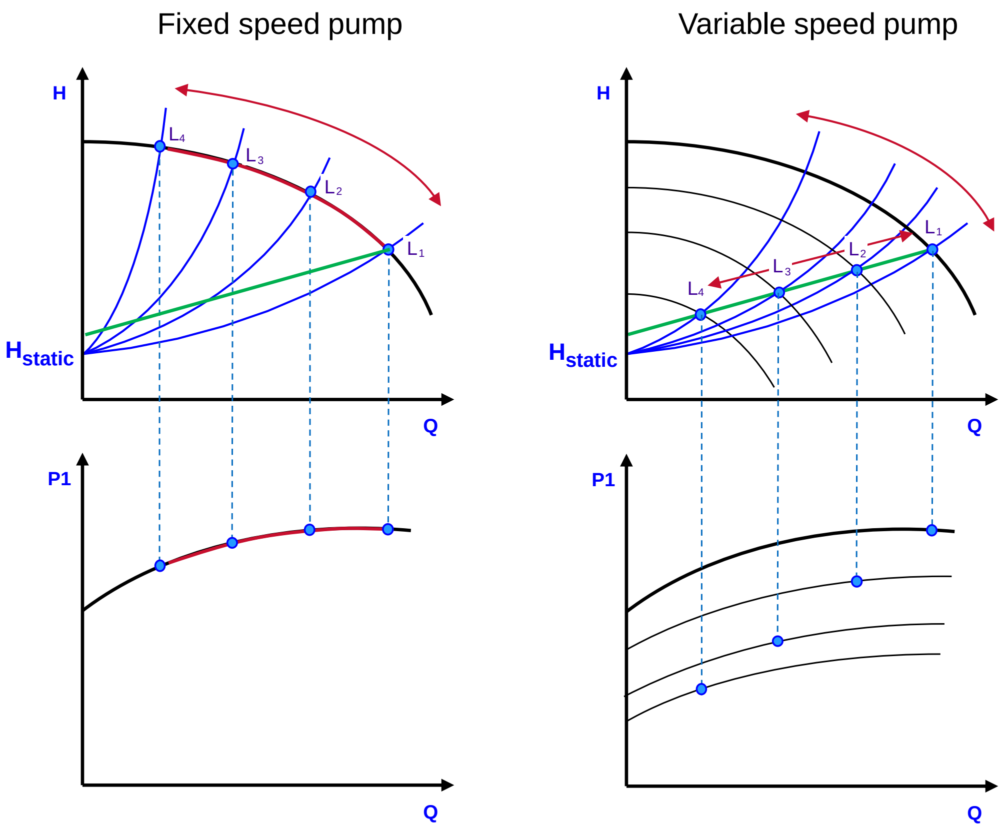
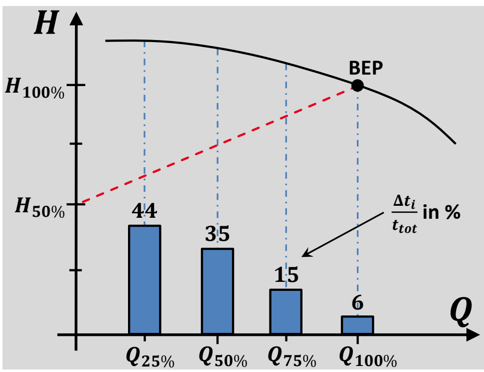


Figure 6 Reference control curve for variable flow systems

As shown on Figure 6 a reference control like this will imply that a variable speed pump will have considerable lower power input at part load compared to a fixed speed pump. This means that a variable speed pump, which can operate closer to or at the reference control curve will be rated with a lower (i.e. better EEI) in a variable flow system compared to a fixed speed pump in these systems.

3.2.2 Flow-time profile for variable flow systems

Based on studies of HVAC systems a load time profile has been developed [6]. The load profile for these systems is shown in Figure 1



	Flow [%]	Time [%]
L_1	100	6
L_2	75	15
L_3	50	35
L_4	25	44

Figure 7 Flow-time profile variable flow systems

The flow-time profile distribution shows that these pumps are running a significant amount of the time at part load nearly 80% of the time at 50% load or below and only 6% of the time at full load. This is due to the heating and cooling load and the nonlinearities in the emission systems.

It was decided that this load profile could be used for other variable flow open loop and closed systems: This means that for variable flow systems the flow-time profile shown in Figure 7 together with the reference control curve in Figure 6 must be used when calculating EEI for pumps used in those systems

3.3 Pressure boosting

Pressure boosting is under development and will be included at a later stage

3.4 Relation between system types and pump types

There is no one-to-one mapping between system types and pump types. Some pump types are used in different systems. Table 1 shows the relation between system types and pump types.

Table 1 System type vs. pump type

Pump type	Relation to EuP/ErP	System type	
		Variable flow	Constant flow
Circulators	Lot 11	X	
ESCCI	Lot 11	X	X
ESOB	Lot 11	X	X
ESCC	Lot 11	X	X
MS	Lot 11	X	X
MSS	Lot 11	O	X
Wastewater pumps	Lot 28	tbd	tbd
Clean water pumps	Lot 29 (except Lot 11 pump types, which follows the above split)	tbd	tbd

For pump types used in more than one system type, more than one EEI value will be calculated. The *product information requirements* must ensure that the EEI is calculated and documented for all the entries in the table marked with an ‘X’. Calculation and documentation of an EEI are optional for the entries marked with an ‘O’ in the table.

The *energy efficiency requirements* must specify that when putting an extended product into service, the energy efficiency requirements (in terms of EEI) for a particular pump type used in a particular system type must be met.

4 Methodology for calculation of EEI for extended products

The Energy Efficiency Index (EEI) basically consists of an average power input calculated on a flow-time profile divided by a reference power input.

Figure 8 shows how the power in an extended product is defined. P_1 is the electrical power input from the grid. P_2 is the mechanical power from the motor shaft. P_{hydr} is the hydraulic power produced by the pump.

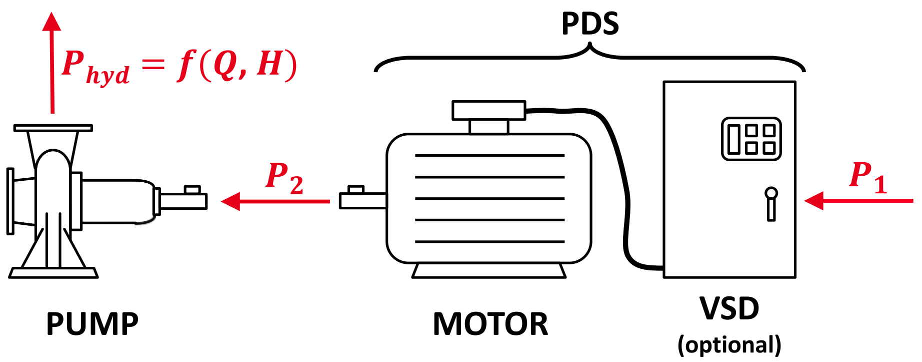


Figure 8 Definition of *Powers* in an extended pump product. The combined motor and CDM (VSD) is referred to as a Power Drive System (PDS)

A graphical presentation of the EEI calculation is shown in Figure 9. The left side shows the calculation of average power input i.e. the numerator of the EEI index. The right side shows how to calculate the reference power i.e. the denominator of the EEI index.

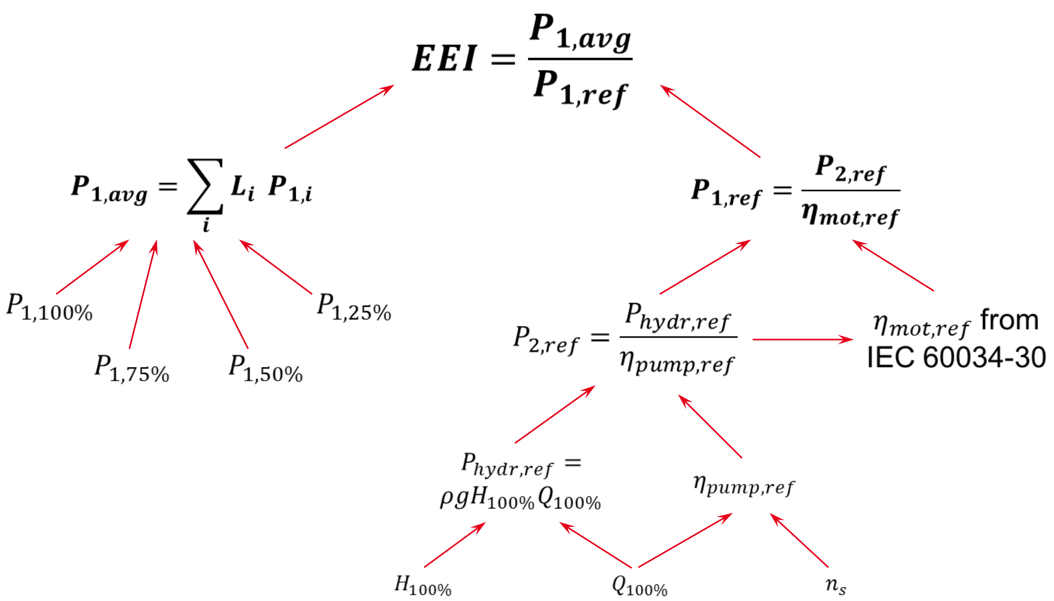


Figure 9 Graphical presentation of the EEI calculation

The power input values $P_{1,i}$ in Figure 9 can be measured, but this is not possible in most cases especially not for separated units. The $P_{1,i}$ values will then be calculated from Semi Analytical Models (SAMs) as described in the next section.

The reference power input based on the efficiency level of the actual pump type and size as defined in the EC regulation for water pumps [3] and will defined for other pump types at a (i.e wastewater pumps and clean water pumps) at a later stage. Based on actual measurements of the pump, the head and the flow at the best efficiency point (H100%, Q100%) is determined and from that the specific speed (ns) is calculated. Based on the hydraulic power and the efficiency, the reference shaft power $P_{2,ref}$ is calculated, which can be converted into a reference power input via the IEC 600034-30 for motors.

The reference power is based on an extended product without VSD. The efficiency of a the specific VSD is captured by the power input values $P_{1,i}$ as is the case for pump and motor.

4.1 Semi Analytical Models (SAMs)

A methodology for an extended pump product cannot be based on measurement only although this is an option, which can be applied in some cases.

Separated extended pump products are in many cases built on site, which makes a determination of EEI based on measurements of the assembled extended product impossible. Therefore a methodology based on Semi Analytical Models (SAMs) has been developed to overcome this problem [8], [9].

A SAM is a model which is based on measurement combined with physical and empirical knowledge of the product. Based on SAMs of the pump, motor and VSD it is possible to calculate the EEI of the extended product based on a few measurement points (supporting points) of the individual products (pump, motor and VSD).

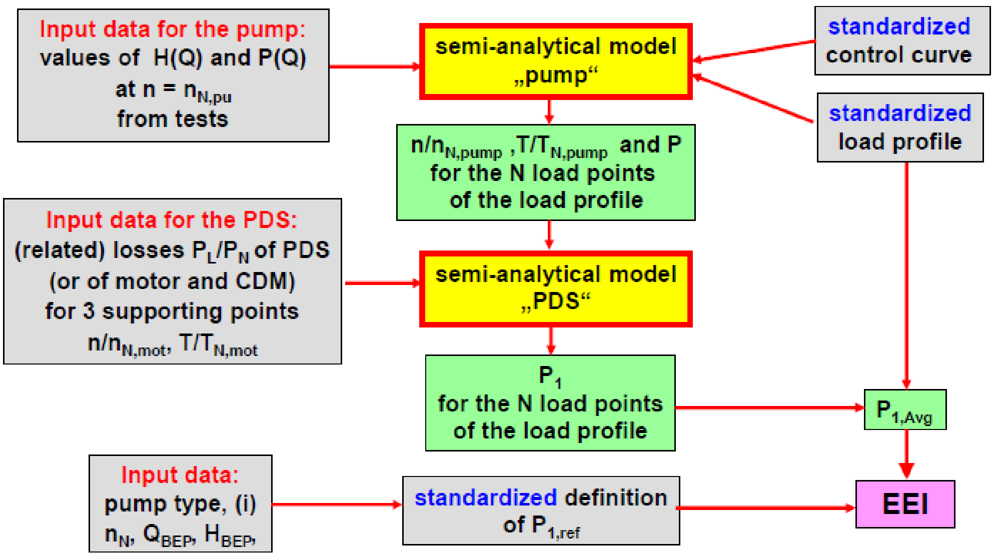


Figure 10 Flow chart for calculating EEI of an Extended Pump Product

Based on the SAM for the pumps, the torque and rotational speed at the part load points are calculated. These part load points are used to determine the power input to the extended product via the PDS model.

The PDS model is described in the CENELEC standards [9] and [10]. Figure 11 shows the eight load points which is defined in these standards. For EEI calculation of the pump in scope only three supporting points are needed. These three points are those on the border of the green shaded area.

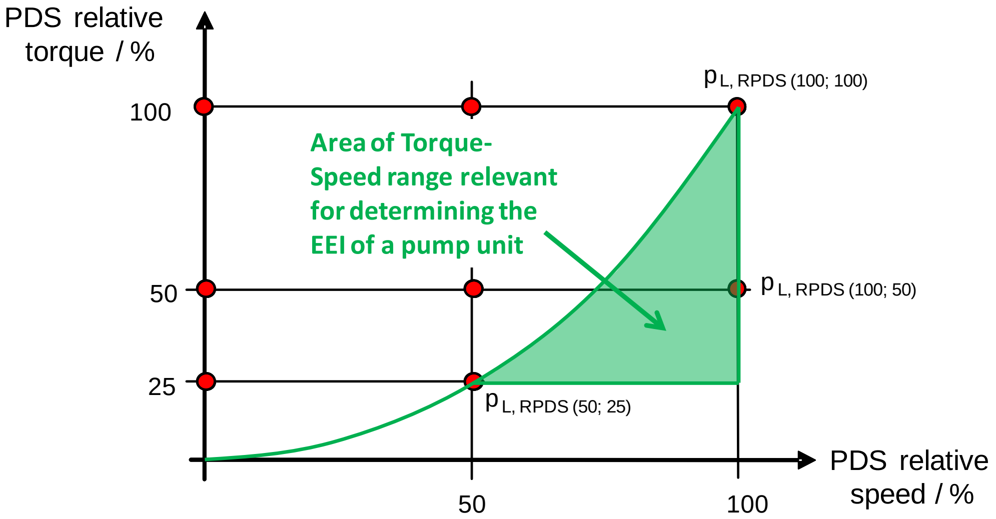


Figure 11 Three points of related losses and shaded area of interest for pump manufacturers when calculating the EEI (Energy Efficiency Index) of a pump unit (Source: [9])

The actual losses will be based on interpolation based on these supporting points. Part 1 of the PDS standard [9] will cover the generic application of the standard for extended products. A specific measurements standard must be written for all products.

A draft CEN standard for calculating EEI for pumps is under development [11], [12].

An example EEI calculation based on the semi-analytical methodology for a fictitious pump unit is described in [10].

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