

4E EMSA – The Motor Systems Tool

Energy Efficient Electric Motor Systems Webinar

Sandie B. Nielsen, Danish Technological Institute
September 10th, 2024

The Motor Systems Tool

- **Sandie B. Nielsen** (sbn@dti.dk)
 - Danish Technological Institute (<http://dti.dk>)
- Electrical Engineer – Motor & Drives specialist, programmer
- Employments:
 - 1996-2001 – ABB (Drives specialist)
 - 2001-2002 – DEFU (Project manager, energy optimization)
 - 2002- present – Danish Technological Institute
 - Business Manager & Head of ISO 17025 accredited testing laboratories
 - Frequency converters, Motors, Pumps, Fans etc. (Range hoods, AHU-Units)
 - Technical consultant for Danish Energy Agency
 - Ecodesign matters on frequency converters, motors, pumps & fans
 - IEC standardization member in several working groups
 - Frequency converters & motors (WG12, WG18, WG28 & WG31)
 - External trainer at Grundfos A/S (pumps and pump applications)
 - Development of data acquisition software and multiple tools in LabVIEW, MST-Tool
 - On-going member & task leader in EMSA since 2009



Sandie B. Nielsen, anno 2023

The Motor Systems Tool

- Introduction to MST-Tool
 - Basic functions
 - Input screens
 - Main Windows
- Some features:
 - Dynamic duty point selection
 - “On the fly” language select
 - Automated slip calculation
 - Eco-design evaluation – water pumps, fans
- Standard features:
 - Motor/Drive models:
 - PM and SynRM loss models
 - IEC reference and typical losses
 - AMCA Models (ANSI/AMCA 207-17)
 - 3 x power transmissions
 - 5 x sets of motor/drive losses
 - Application calculator
 - Pump & Fan
 - Hydraulic machines
 - Air compressors
 - Cooling compressors
- A real-life example

The Motor Systems Tool

- Introduction:

“Motor Systems Tool is an impartial calculator for complete motor systems that utilizes “neutral” models of standardized components, to determine the efficiency at any given duty point on a complete motor system”

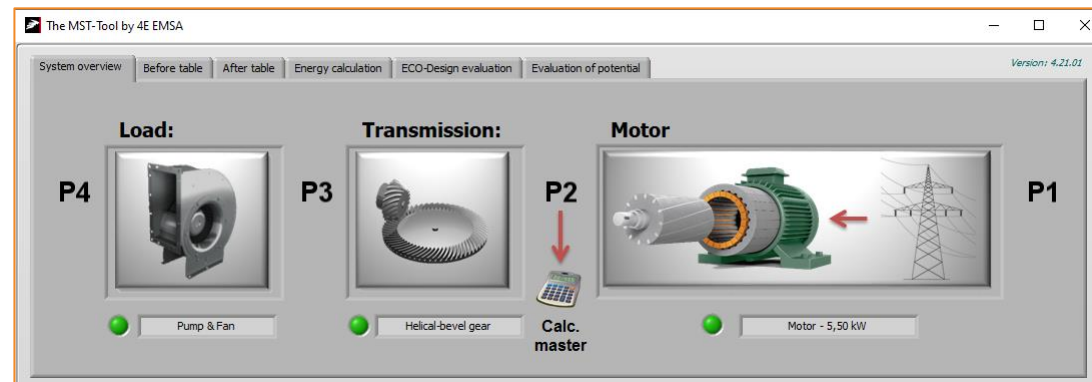
It was firstly introduced at EEMODS’11 in Washington D.C. and has since appeared at several Motor Summit’s & EEMODS’ conferences as well as at multiple workshops

Today, more than 12 years later we have registered more than 4.500 unique downloads!

The Motor Systems Tool

- Basic function:

Selection of three essential components:

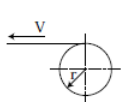
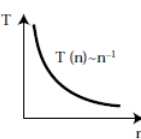
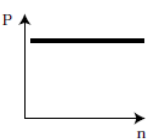
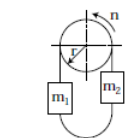
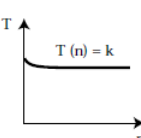
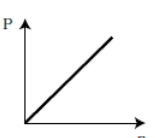
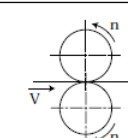
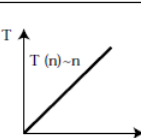
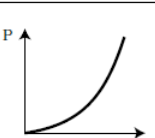
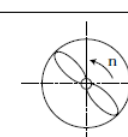
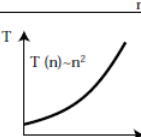
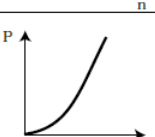


Load Transmission Motor/Drive unit

The Motor Systems Tool

- Load profile:

Input torque profile:

1				Torque is reciprocal of speed <input type="radio"/>	The first group (1) consists of machines for winding material under tension. This group includes, for example veneer cutting machines and machine tools.
2				Torque is constant at all speeds <input type="radio"/>	Group (2) consists of conveyor belts, cranes, positive displacement pumps as well as machine tools.
3				Torque is linear with speed <input type="radio"/>	Group (3) consists of machines such as rollers, smoothing machines and other processing machines.
4				Torque is equal to speed squared <input checked="" type="radio"/>	Group (4) comprises machines operating by centrifugal force, such as centrifuges, centrifugal pumps and fans.

Ok

The Motor Systems Tool

- Transmission:

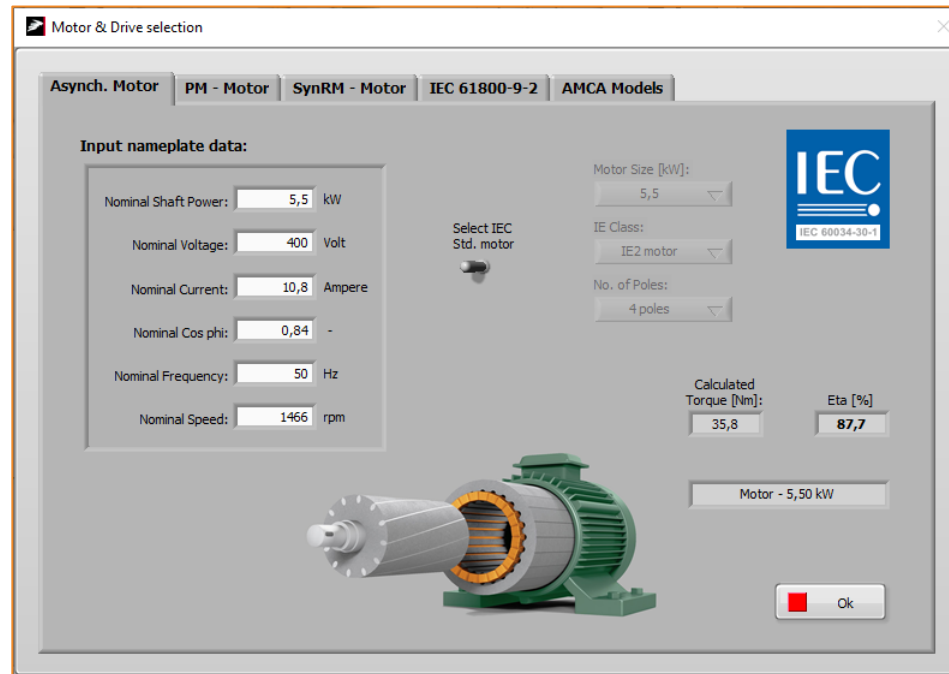
Worm gear
Bevel gear or
Helical gear

Classic V, Narrow V, Poly V
Flat belt or Timing belt

AMCA models for transmission

The Motor Systems Tool

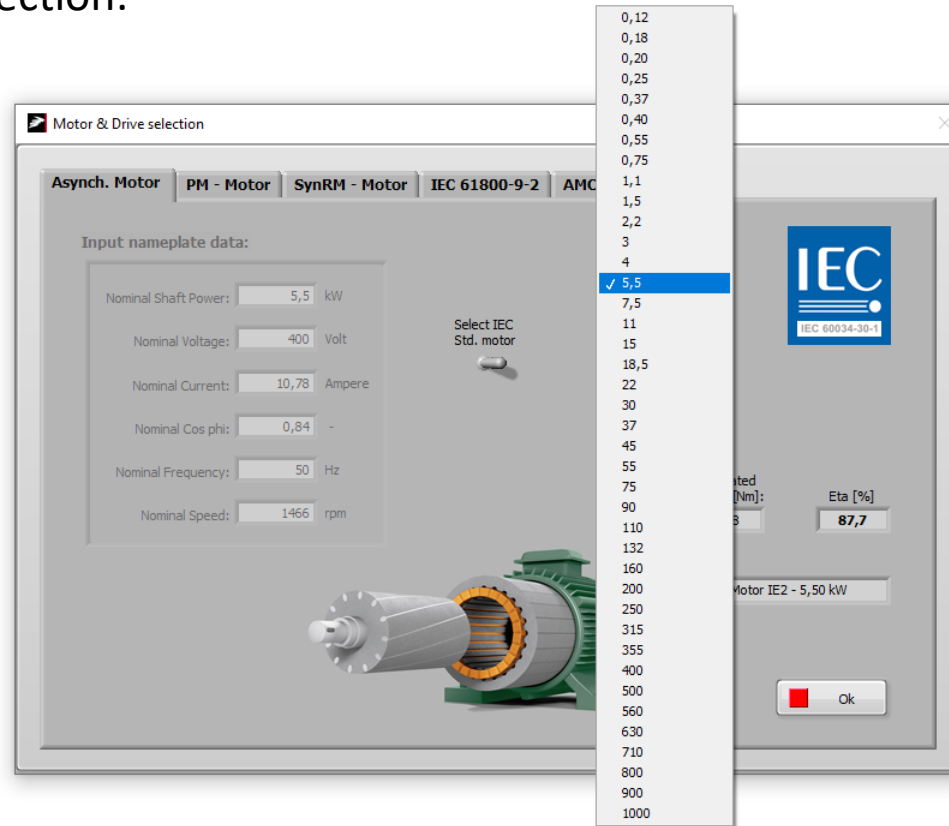
- Motor/Drive unit selection:



Asynchronous motor – 5.5 kW from nameplate

The Motor Systems Tool

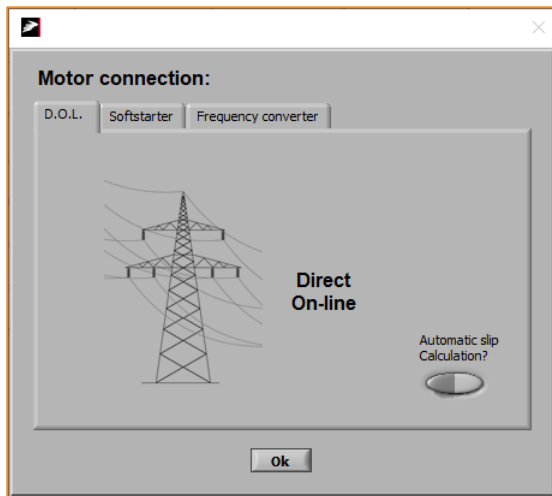
- Motor/Drive unit selection:



Asynchronous motor – 5.5 kW from IEC 60034-30-1 Tables

The Motor Systems Tool

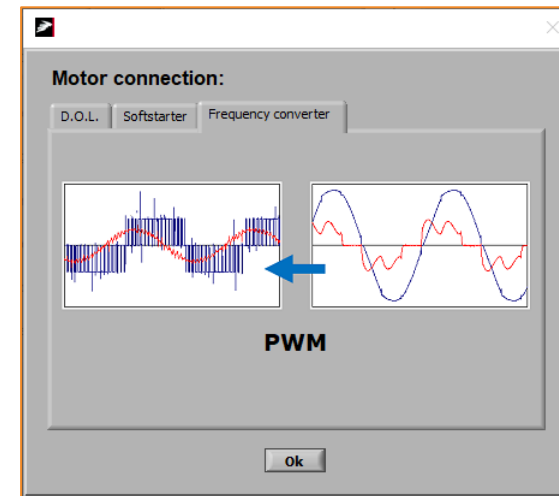
- Motor/Drive unit selection:



Direct On-line



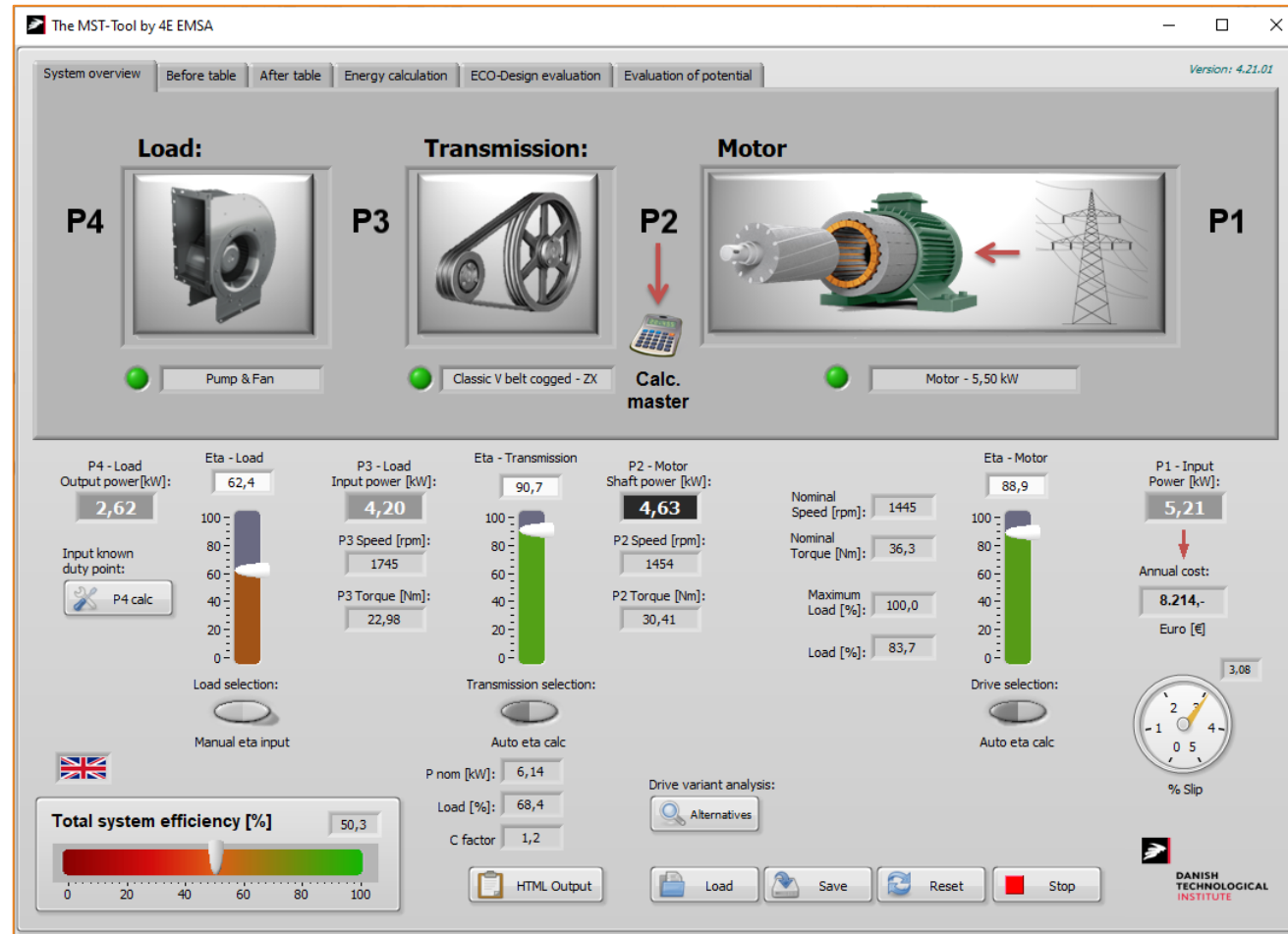
Soft starter



Frequency Converter

The Motor Systems Tool

- Main window:



The Motor Systems Tool

Dynamic duty point selection

- Main window:

The screenshot displays the 'The MST-Tool' software interface. A 'Calc. master' dialog box is open, showing the following values:

- P2 - Motor Shaft power [kW]: 4,63
- P2 Speed [rpm]: 1454
- P2 Torque [Nm]: 30,41

The main window shows a system overview with the following components and parameters:

- P4 - Load:** Output power [kW]: 2,62; Input known duty point: P4 calc.
- Eta - Load:** Efficiency bar chart (approx. 80%).
- P3 - Load:** Input power [kW]: 4,20; P3 Speed [rpm]: 1745; P3 Torque [Nm]: 22,98.
- Eta - Transmission:** Efficiency bar chart (approx. 90%).
- P2 - Motor:** Shaft power [kW]: 4,63; P2 Speed [rpm]: 1454; P2 Torque [Nm]: 30,41.
- Eta - Motor:** Efficiency bar chart (approx. 85%).
- P1 - Input Power [kW]:** 5,21; Annual cost: 8.214,- Euro [€]; % Slip: 3,08.

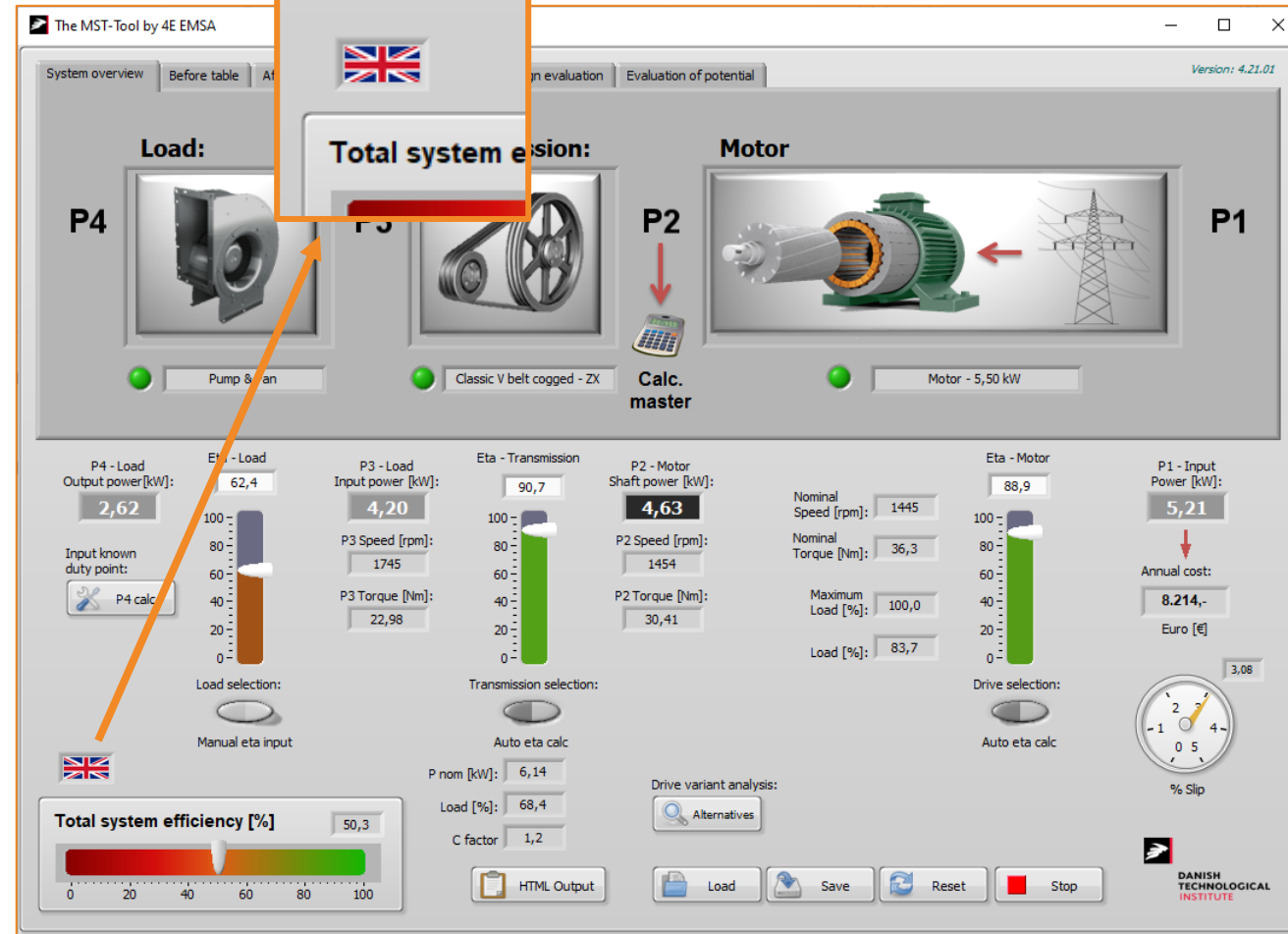
Additional parameters and controls include:

- Drive selection: Auto eta calc.
- Drive variant analysis: Alternatives.
- Buttons: HTML Output, Load, Save, Reset, Stop.
- Logos: DANISH TECHNOLOGICAL INSTITUTE.

The Motor Systems Tool

Dynamic language selection, switch “On the fly”

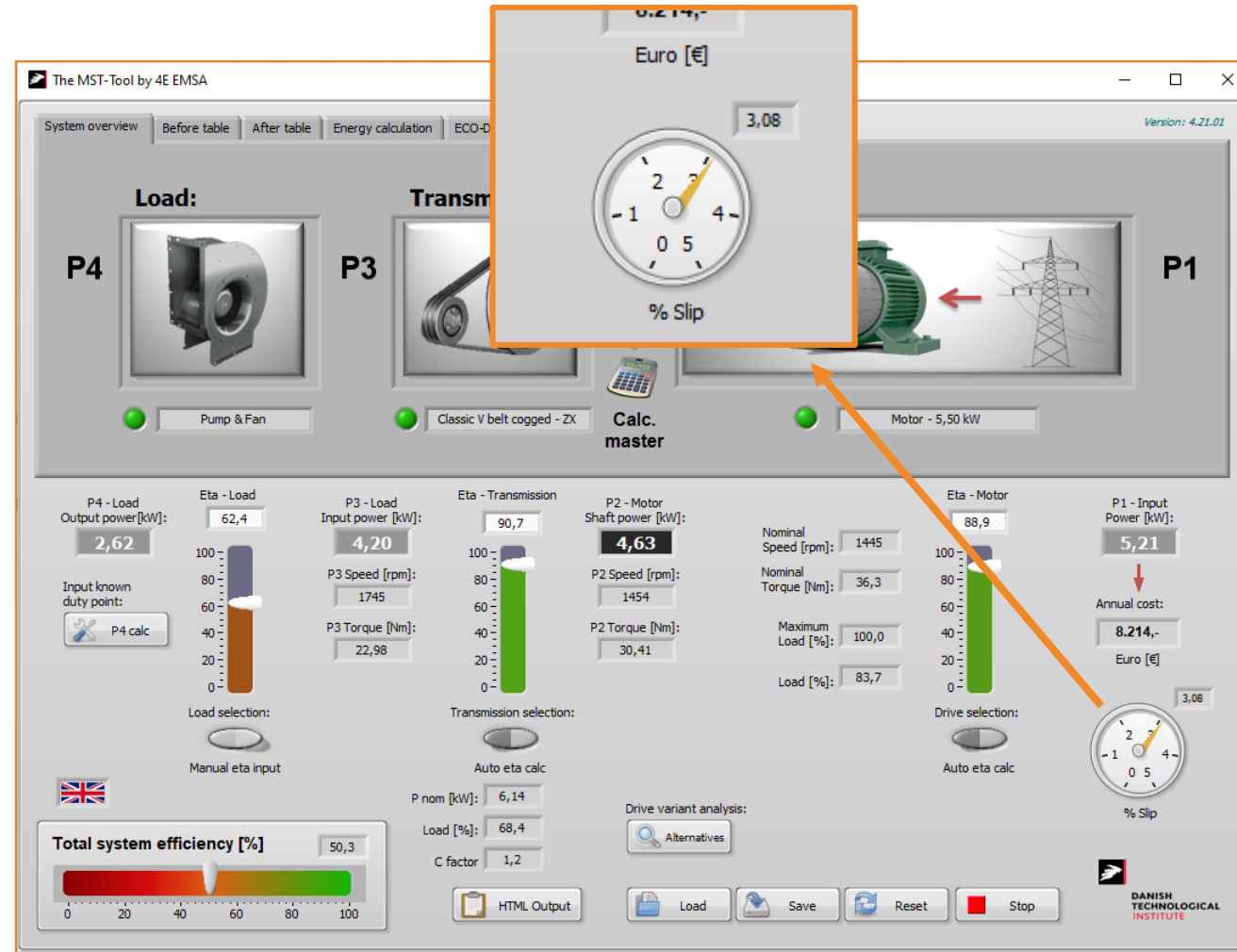
- Main window:



The Motor Systems Tool

Automatic slip calculator (D.O.L. machines)

- Main window:



The Motor Systems Tool

- Main window:

Annual cost – on the fly

The screenshot displays the main window of 'The MST-Tool by 4E EMSA'. The interface is divided into several sections:

- System overview:** Includes tabs for 'System overview', 'Before table', 'After table', 'Energy calculation', 'ECO-Design evaluation', and 'Evaluation of potential'.
- Load (P4):** 'Pump & Fan' with a green status indicator.
- Transmission (P3):** 'Classic V belt cogged - ZX' with a green status indicator.
- Motor (P2):** 'Motor - 5,50 kW' with a green status indicator. A 'Calc. master' button is located below the motor icon.
- Energy flow diagram:** Shows power flow from P1 (Input Power) through P2 (Motor), P3 (Transmission), and P4 (Load).
- Parameters and Gauges:**
 - P4 - Load:** Output power [kW]: 2,62; Input known duty point: P4 calc.
 - Eta - Load:** Gauge showing efficiency.
 - P3 - Load:** Input power [kW]: 4,20; P3 Speed [rpm]: 1745; P3 Torque [Nm]: 22,98.
 - Eta - Transmission:** Gauge showing efficiency.
 - P2 - Motor:** Shaft power [kW]: 4,63; P2 Speed [rpm]: 1454; P2 Torque [Nm]: 30,41.
 - Eta - Motor:** Gauge showing efficiency.
 - P1 - Input Power:** Input Power [kW]: 5,21; Annual cost: 8.214,- Euro [€].
- Summary and Controls:**
 - Total system efficiency [%]:** 50,3 (shown on a color scale bar).
 - Drive variant analysis:** Includes 'Alternatives' button.
 - Buttons:** HTML Output, Load, Save, Reset, Stop.
 - Logos:** DANISH TECHNOLOGICAL INSTITUTE.

P1 - Input Power [kW]:
5,21
↓
Annual cost:
8.214,-
Euro [€]

The Motor Systems Tool

- Main window:

The screenshot displays the main window of 'The MST-Tool by 4E EMSA'. The interface is organized into several sections:

- System overview:** Includes tabs for 'Before table', 'After table', 'Energy calculation', 'ECO-Design evaluation', and 'Evaluation of potential'. The version is 4.21.01.
- Load (P4):** Represented by a 'Pump & Fan' icon. Output power is 2,62 kW.
- Transmission (P3):** Represented by a 'Classic V belt cogged - ZX' icon. Input power is 4,20 kW, P3 Speed is 1745 rpm, and P3 Torque is 22,98 Nm.
- Motor (P2):** Represented by a 'Motor - 5,50 kW' icon. Shaft power is 4,63 kW, P2 Speed is 1454 rpm, and P2 Torque is 30,41 Nm.
- Input (P1):** Input power is 5,21 kW, resulting in an annual cost of 8.214,- Euro.

Key performance indicators and settings include:

- Total system efficiency [%]:** 50,3 (indicated by a red-to-green bar chart).
- Efficiency (Eta) gauges:** Eta - Load (62,4%), Eta - Transmission (90,7%), and Eta - Motor (88,9%).
- Drive variant analysis:** Includes 'Alternatives' and 'Auto eta calc' options.
- Buttons:** HTML Output, Load, Save, Reset, and Stop.

A callout box labeled 'Visual save of setup' points to the 'Save' button.

The Motor Systems Tool

Save duty points – Before situation

- Main window:

The screenshot displays the 'Before table' tab in the MST-Tool software. It features a 'Snapshots' section with a table of data points and several interactive control panels for system parameters.

Par. A	Par. B	P4 [kW]	Eta load	P3 [kW]	P3 [rpm]	Eta trans.	P2 [kW]	P2 [rpm]	Eta motor	Eta VSD	P1 [kW]	Eta total	Hours/year	Days/year	kWh/year
8	444	3,115	62,4	4,992	1737	90,77	5,5	1448	100	83,92	6,554	47,53	1200	50	7865
8	444	2,339	55,7	4,199	1747	90,69	4,63	1456	100	84,35	5,489	42,61	2500	104	13720
8	444	0,747	46,3	1,613	1780	88,63	1,82	1483	100	79,58	2,287	32,66	3800	158	8690
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Key performance indicators and controls shown in the interface include:

- P4 - Load Output power [kW]:** 2,62
- Eta - Load:** 62,4
- P3 - Load Input power [kW]:** 4,20
- Eta - Transmission:** 90,7
- P2 - Motor Shaft power [kW]:** 4,63
- Eta - Motor:** 88,9
- P1 - Input Power [kW]:** 5,21
- Annual cost:** 8.214,- Euro [€]
- Total system efficiency [%]:** 50,3
- % Slip:** 3,08

The Motor Systems Tool

Save duty points – After situation

- Main window:

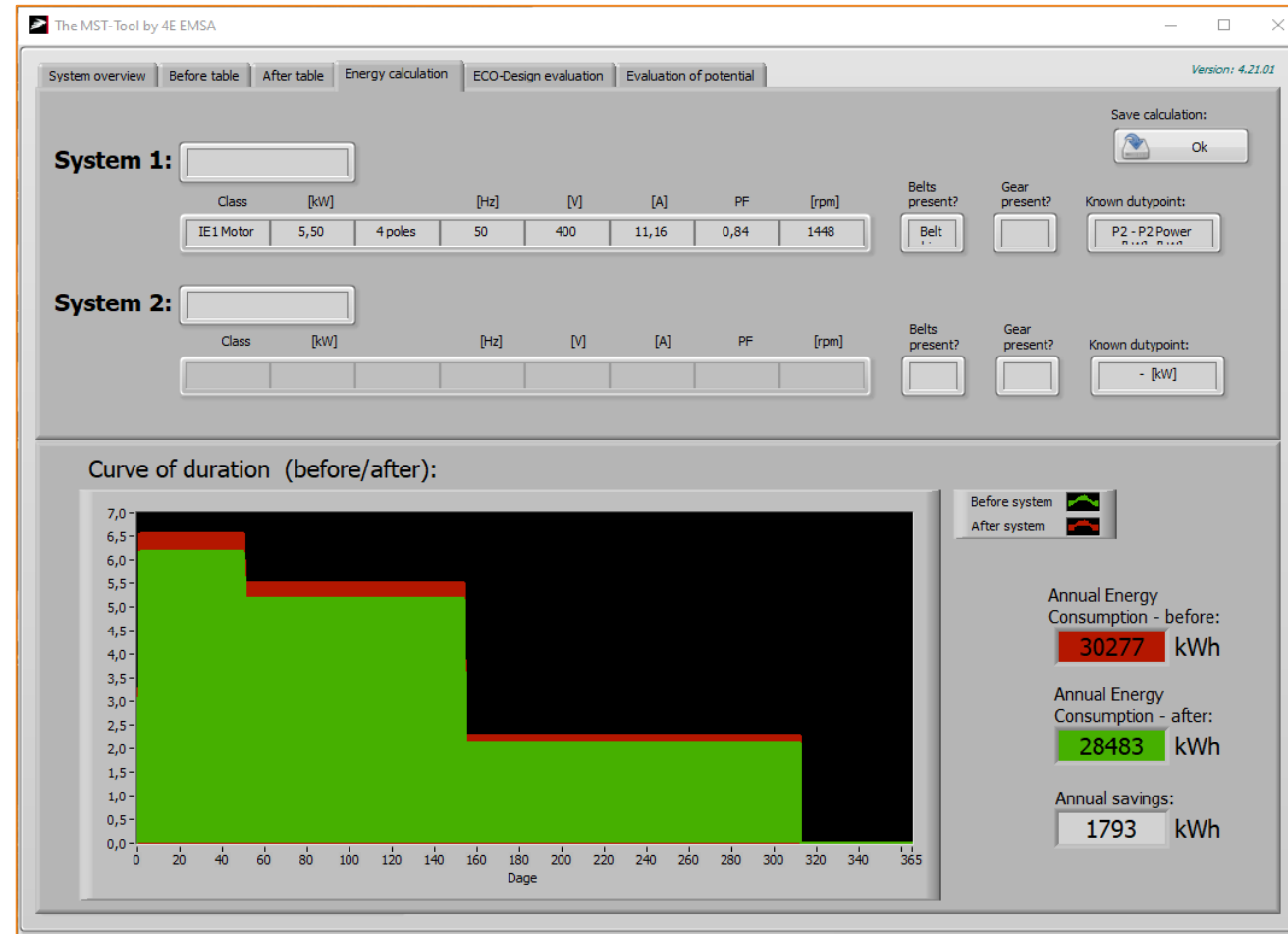
The screenshot displays the main window of 'The MST-Tool by 4E EMSA'. The interface includes a menu bar with options like 'System overview', 'Before table', 'After table', 'Energy calculation', 'ECO-Design evaluation', and 'Evaluation of potential'. The 'Snapshots' section features a table with columns for parameters (Par. A, Par. B), power (P4, P3, P2, P1), efficiency (Eta), speed (rpm), torque (Nm), and usage (Hours/year, Days/year, kWh/year). Below the table, there are several control panels for 'P4 - Load', 'Eta - Load', 'P3 - Load', 'Eta - Transmission', 'P2 - Motor', 'Eta - Motor', and 'P1 - Input Power'. Each panel includes a numerical value, a vertical bar chart, and a 'Manual eta input' or 'Auto eta calc' option. A 'Total system efficiency [%]' bar is shown at the bottom left, and a '% Slip' gauge is at the bottom right. The software version '4.21.01' is noted in the top right corner.

Par. A	Par. B	P4 [kW]	Eta load	P3 [kW]	P3 [rpm]	Eta trans.	P2 [kW]	P2 [rpm]	Eta motor	Eta VSD	P1 [kW]	Eta total	Hours/year	Days/year	kWh/year
8	444	3,115	62,4	4,992	1777	90,77	5,5	1480	100	89,03	6,177	50,43	1200	50	7413
8	444	2,339	55,7	4,199	1780	90,69	4,63	1483	100	89,26	5,187	45,09	2500	104	12970
8	444	0,747	46,3	1,613	1791	88,63	1,82	1493	100	85,35	2,132	35,02	3800	158	8103
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

The Motor Systems Tool

Instant savings calculated

- Main window:



The Motor Systems Tool

Evaluation for European ecodesign, Fans

- Main window:

The screenshot shows the main window of 'The MST-Tool by 4E EMSA' in the 'ECO-Design evaluation' tab. The interface is titled 'Eco-design no. 327/2011 : Fans'. It includes a 3D model of a fan and several input fields: 'Fan within scope?' (checked), 'BEP demand from Eco no. 327/2011:' (38,2), 'C factor' (1,00), 'Corrected Eta [-]' (49,4), 'Eta type' (Static), and 'Fan type' (Axial fan). A text box on the right states: 'Eco-design requirements for fans driven by motors are as follows: From 1 January 2015, fans driven by motors shall have: a minimum efficiency at the best efficiency point (BEP) as calculated here. For market surveillance a 10% tolerance on the figure above are allowed. The MST-Tool eco-design evaluation are not conclusive! It is only ment as an indicator for a given situation - for compliancy check, a certified laboratory test is necessary.'

The bottom section displays various performance metrics with bar charts and gauges:

- P4 - Load Output power [kW]:** 2,62
- Input known duty point:** P4 calc
- Eta - Load:** 62,4
- P3 - Load Input power [kW]:** 4,20
- P3 Speed [rpm]:** 1765
- P3 Torque [Nm]:** 22,71
- Eta - Transmission:** 90,7
- P2 - Motor Shaft power [kW]:** 4,63
- P2 Speed [rpm]:** 1471
- P2 Torque [Nm]:** 30,05
- Eta - Motor:** 87,3
- P1 - Input Power [kW]:** 5,30
- Annual cost:** 8.358,- Euro [€]
- % Slip:** 1,92
- Total system efficiency [%]:** 49,4
- P nom [kW]:** 6,14
- Load [%]:** 68,4
- C factor:** 1,2

Additional controls include 'Load selection' (Manual eta input), 'Transmission selection' (Auto eta calc), 'Drive selection' (Auto eta calc), and 'Drive variant analysis' (Alternatives). A 'Total system efficiency [%]' gauge is at the bottom left, and a 'Danish Technological Institute' logo is at the bottom right. Navigation buttons for 'HTML Output', 'Load', 'Save', 'Reset', and 'Stop' are also present.

The Motor Systems Tool

Evaluation for European ecodesign, Fans

- Main window:

The MST-Tool by 4E EMSA

System overview Before table After table Energy calculation **ECO-Design evaluation** Evaluation of potential Version: 4.21.01

Eco-design no. 327/2011 : Fans

Fan within scope?

BEP demand from Eco no. 327/2011: Fan passes Eco-design?

C factor

Corrected Eta [-]

Eta type Static Dynamic

Fan type

It is only ment as an indicator for a given situation
- for compliancy check, a certified laboratory test is necessary.

Parameter	Value
P4 - Load Output power [kW]	2,62
P3 - Load Input power [kW]	4,20
P2 - Motor Shaft power [kW]	4,63
P1 - Input Power [kW]	5,30
Annual cost [Euro]	8.358,-
% Slip	1,92
Total system efficiency [%]	49,4

Drive variant analysis:

DANISH TECHNOLOGICAL INSTITUTE

The Motor Systems Tool

Evaluation for European ecodesign, Pumps

- Main window:

The screenshot displays the 'Eco-Design evaluation' window of 'The MST-Tool by 4E EMSA'. The interface includes a navigation bar with tabs for 'System overview', 'Before table', 'After table', 'Energy calculation', 'ECO-Design evaluation', and 'Evaluation of potential'. The current view is titled 'Eco-design no. 547/2012 : Water pumps'.

Eco-design requirements for water pumps are as follows:
From 1 January 2015, water pumps shall have:
a minimum efficiency at the best efficiency point (BEP) as calculated here
a minimum efficiency at part load (PL) of at least $(\text{Eta PL} = 0.947 \cdot \text{Eta BEP})$
a minimum efficiency at over load (OL) of at least $(\text{Eta OL} = 0.985 \cdot \text{Eta BEP})$
For market surveillance a 5% tolerance on the figures above are allowed
The MST-Tool eco-design evaluation are not conclusive!
It is only ment as an indicator for a given situation
- for complancy check, a certified laboratory test is necessary.

Eco-design no. 547/2012 : Water pumps
Pump type: ESCC
BEP demand from Eco no. 547/2012: 68,6
Pump passes Eco-design?

From application calculator:
Flow [m3/h]: 55,00
Head [m]: 22,00

Performance Metrics:
P4 - Load Output power [kW]: 3,29
Eta - Load: 78,4
P3 - Load Input power [kW]: 4,20
P3 Speed [rpm]: 1765
P3 Torque [Nm]: 22,71
Eta - Transmission: 90,7
P2 - Motor Shaft power [kW]: 4,63
P2 Speed [rpm]: 1471
P2 Torque [Nm]: 30,05
Eta - Motor: 87,3
P1 - Input Power [kW]: 5,30
Annual cost: 8.358,- Euro [€]
% Slip: 1,92

System Parameters:
Nominal Speed [rpm]: 1466
Nominal Torque [Nm]: 35,8
Maximum Load [%]: 100,0
Load [%]: 83,9
Drive selection: Auto eta calc
P nom [kW]: 6,14
Load [%]: 68,4
C factor: 1,2

Efficiency Summary:
Total system efficiency [%]: 62,1

Additional features include a 'P4 calc' button, a 'Manual eta input' option, a 'Drive variant analysis' section with an 'Alternatives' button, and a 'HTML Output' button. The interface also features a 'Load' button, 'Save', 'Reset', and 'Stop' buttons, and the logo of the Danish Technological Institute.

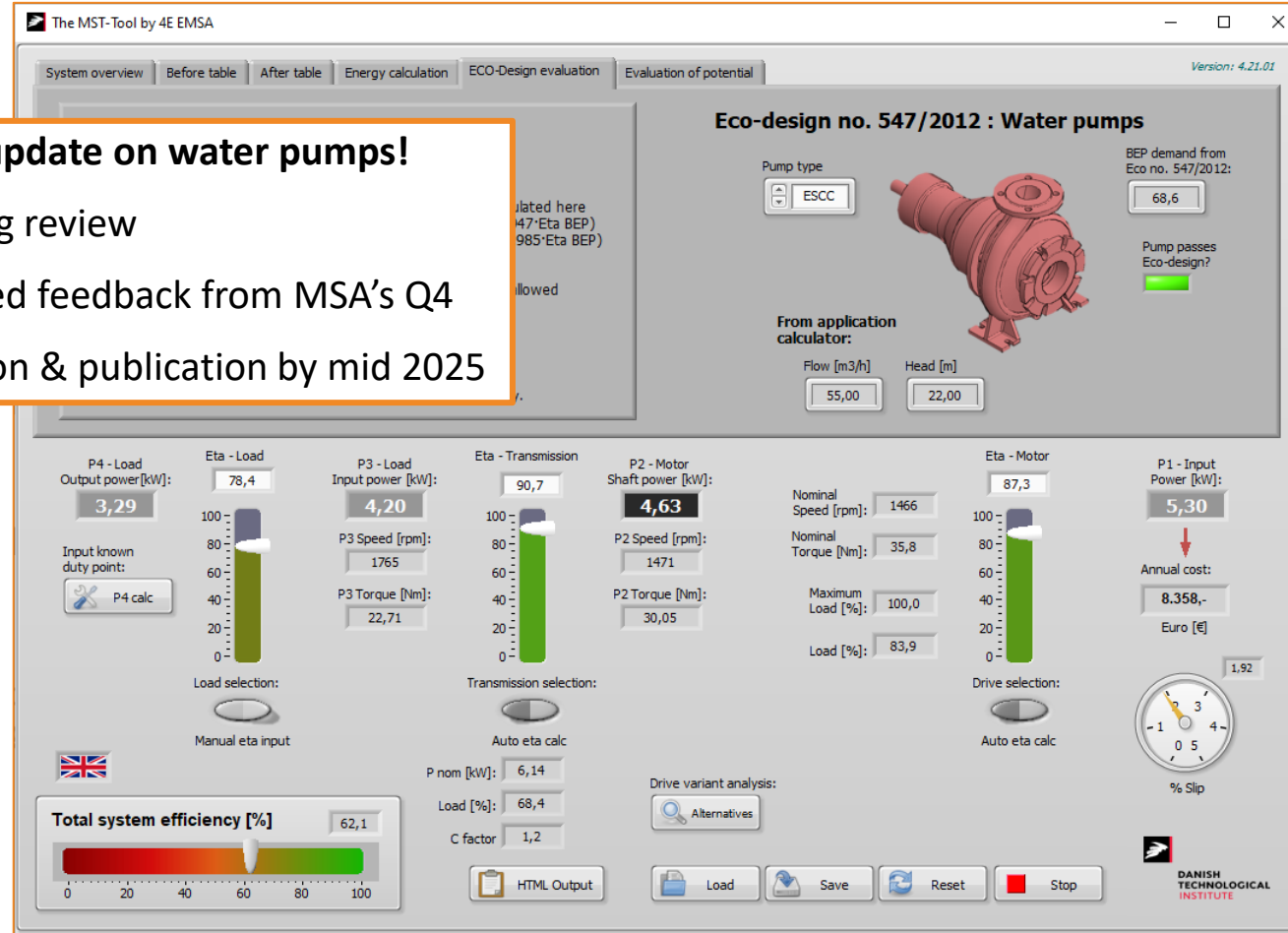
The Motor Systems Tool

Evaluation for European ecodesign, Pumps

- Main window:

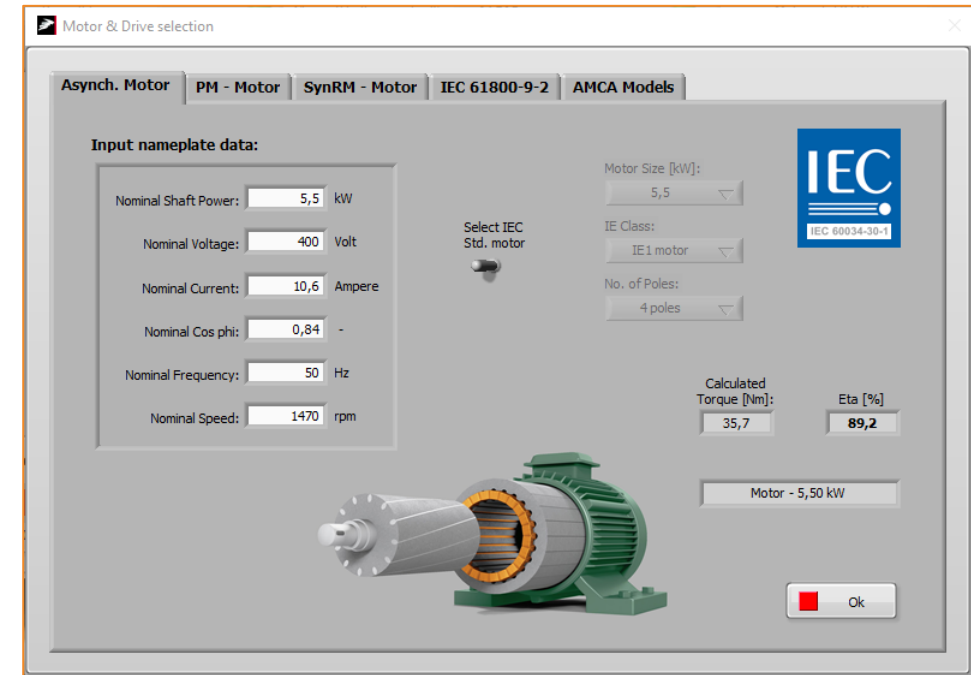
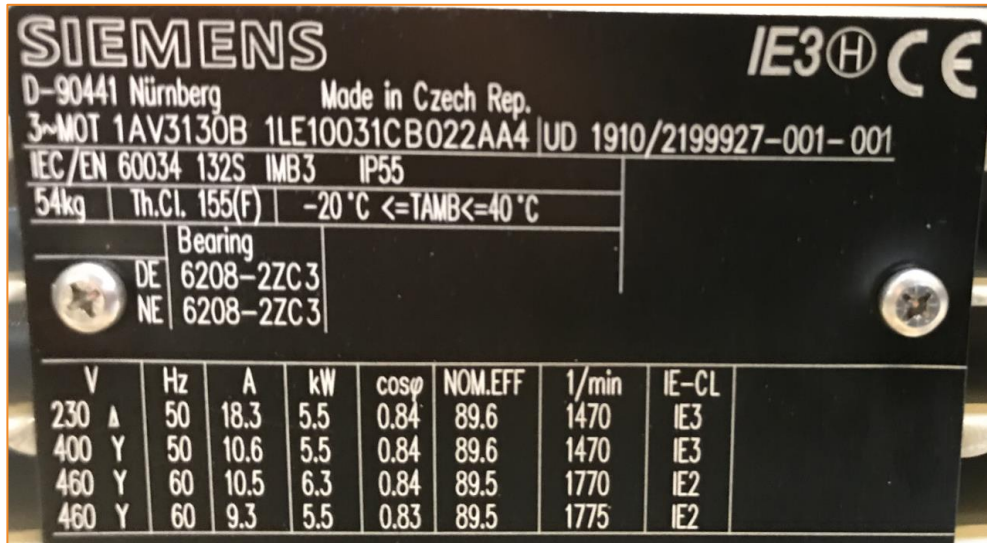
Expected update on water pumps!

- Ongoing review
- Expected feedback from MSA's Q4
- Adoption & publication by mid 2025



The Motor Systems Tool

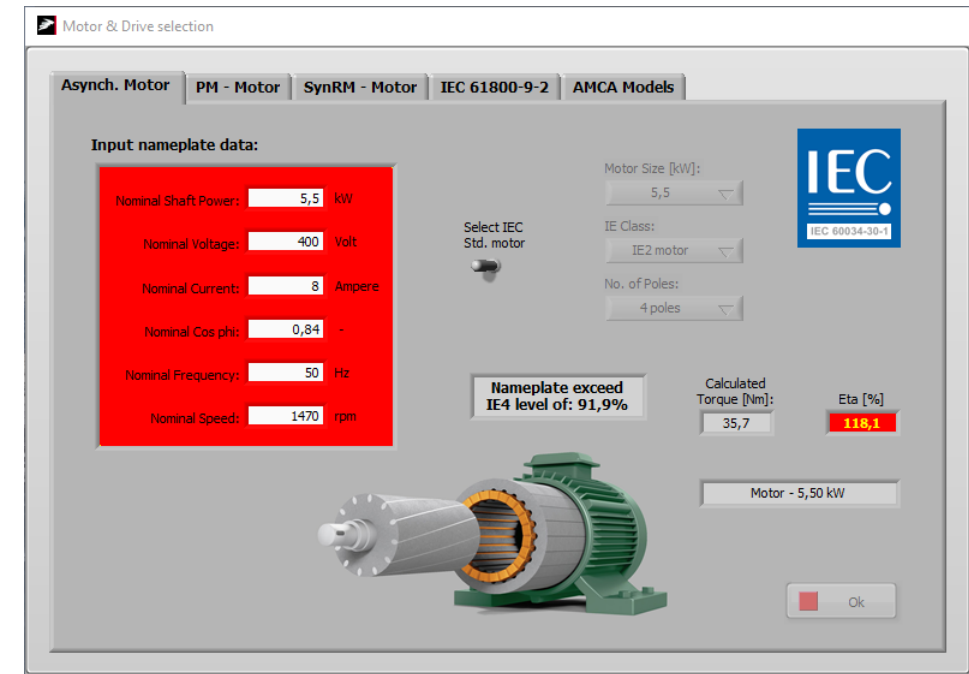
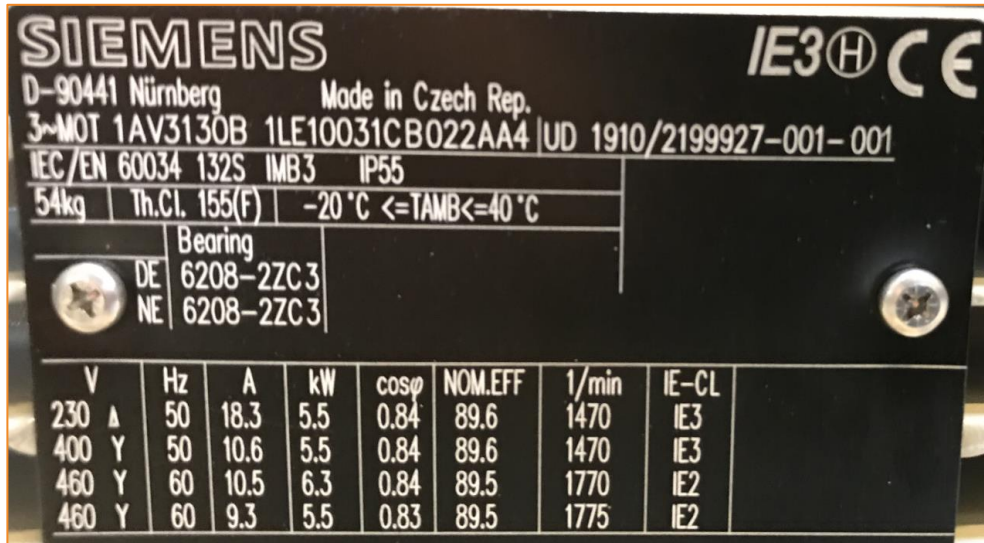
- Motor/Drive unit selection:
 - Input directly from the motor nameplate



Asynchronous motor – 5.5 kW from nameplate

The Motor Systems Tool

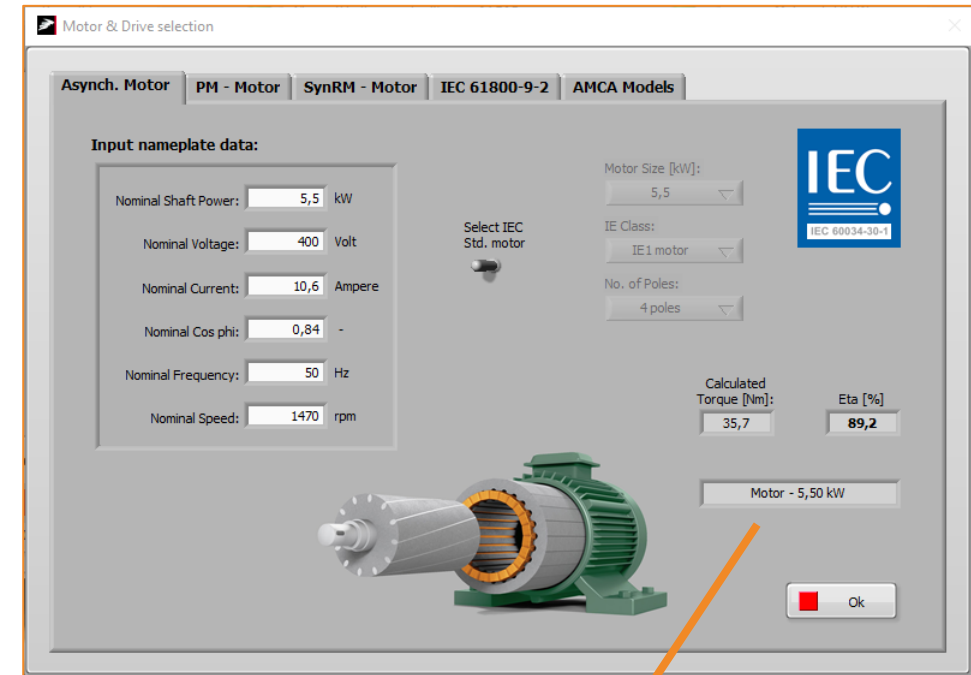
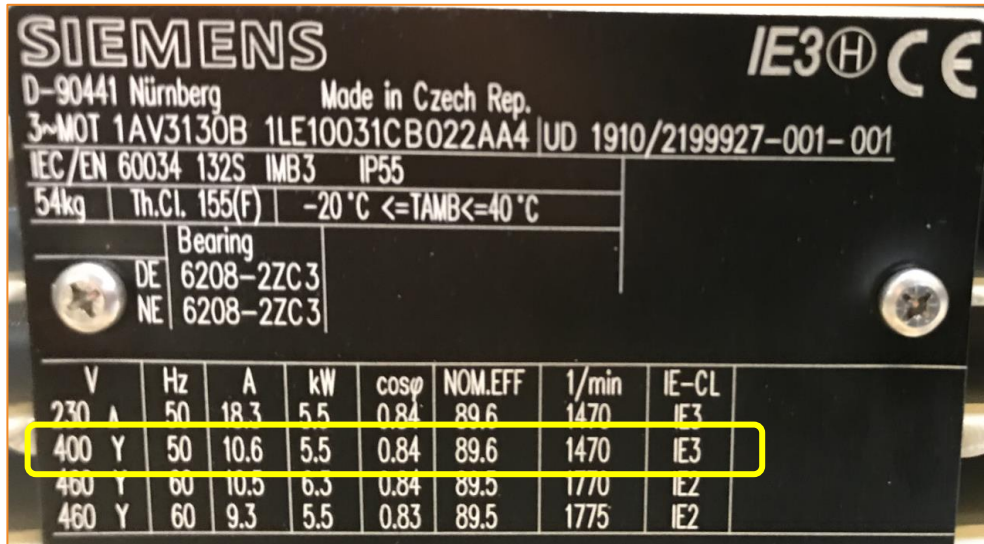
- Motor/Drive unit selection:
 - Input directly from the motor nameplate



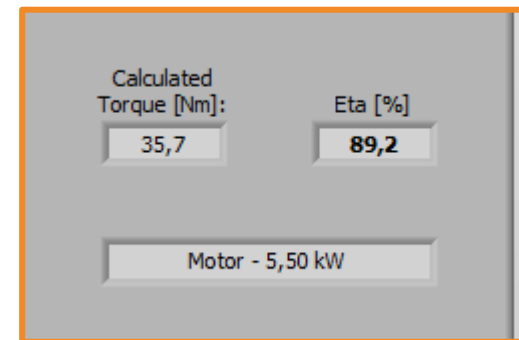
Warning based on calculated efficiency

The Motor Systems Tool

- Motor/Drive unit selection:
 - Input directly from the motor nameplate

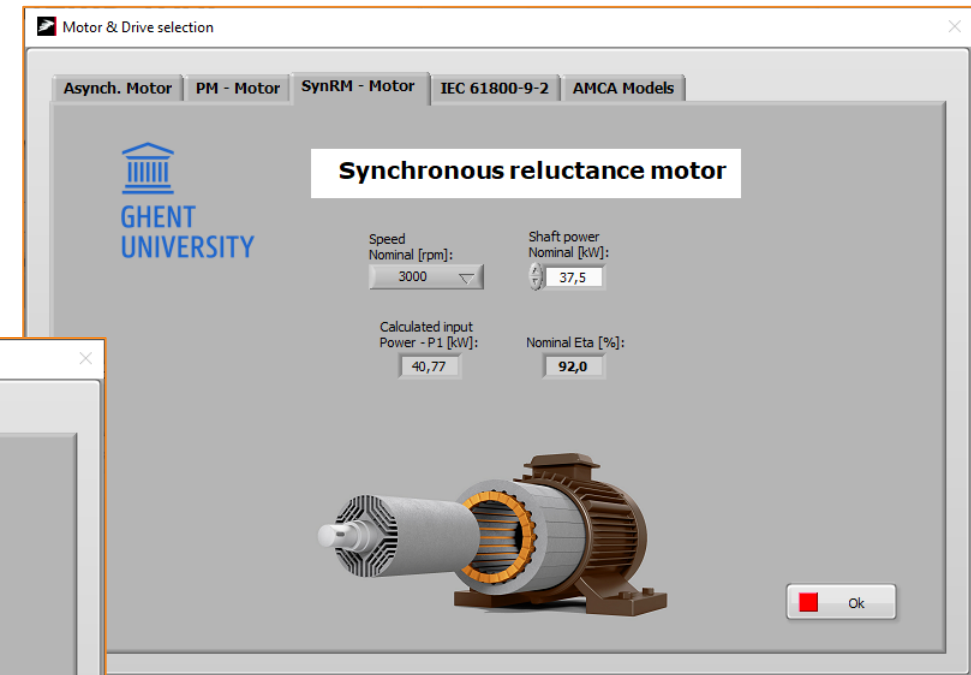
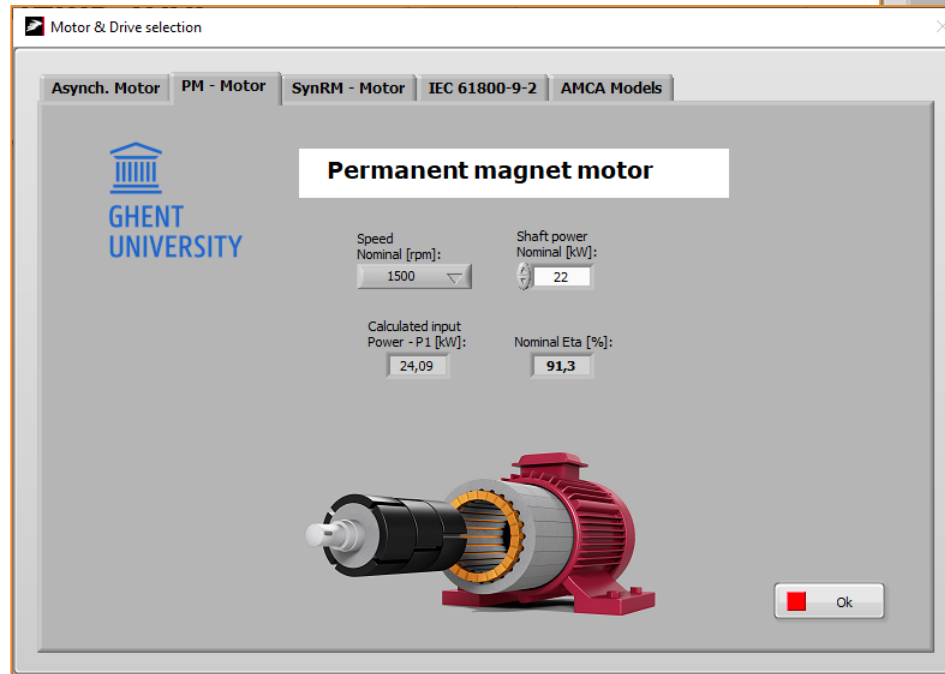


Asynchronous motor – 5.5 kW from nameplate



The Motor Systems Tool

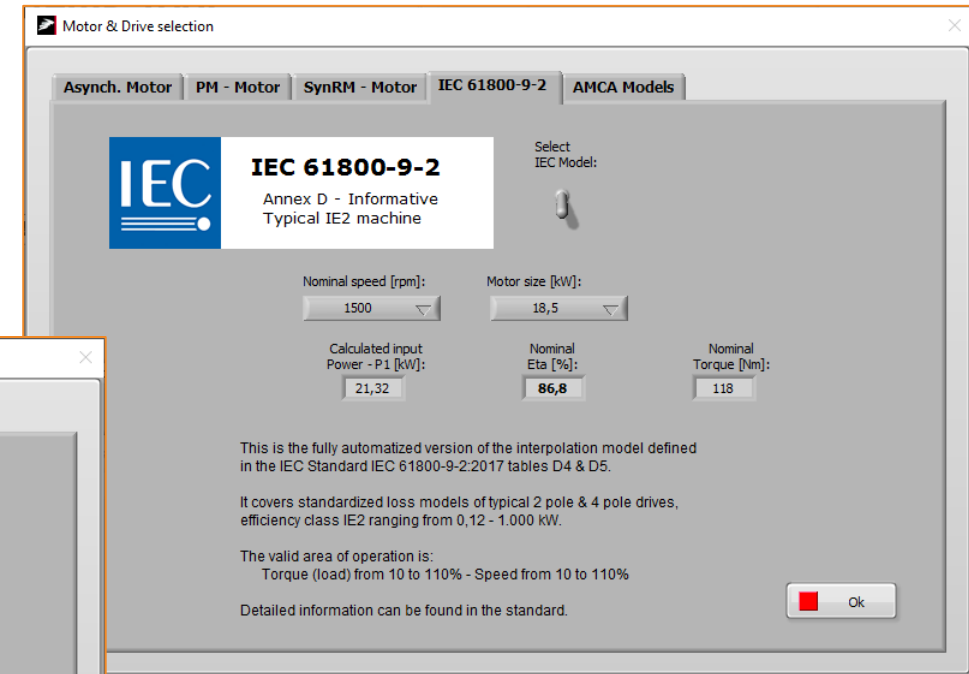
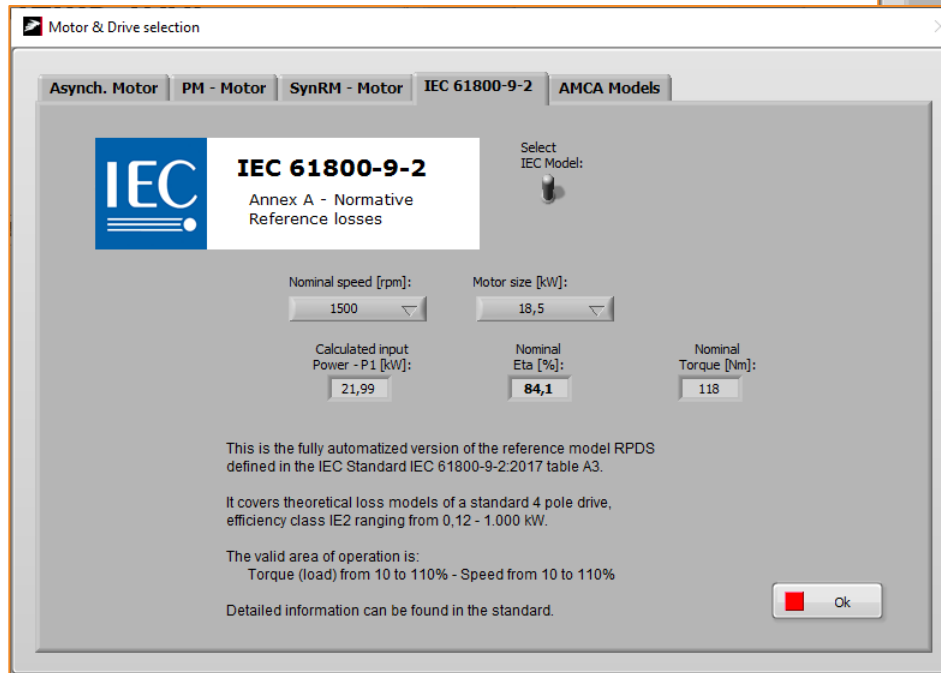
- Motor/Drive unit selection:
 - Permanent magnet & Synchronous reluctance motors
Models from Ghent University



- Models validated in:
 - Shaft power
 - 0.25 – 250 kW
 - Nominal speeds
 - 1.000, 1.500 & 3.000 rpm

The Motor Systems Tool

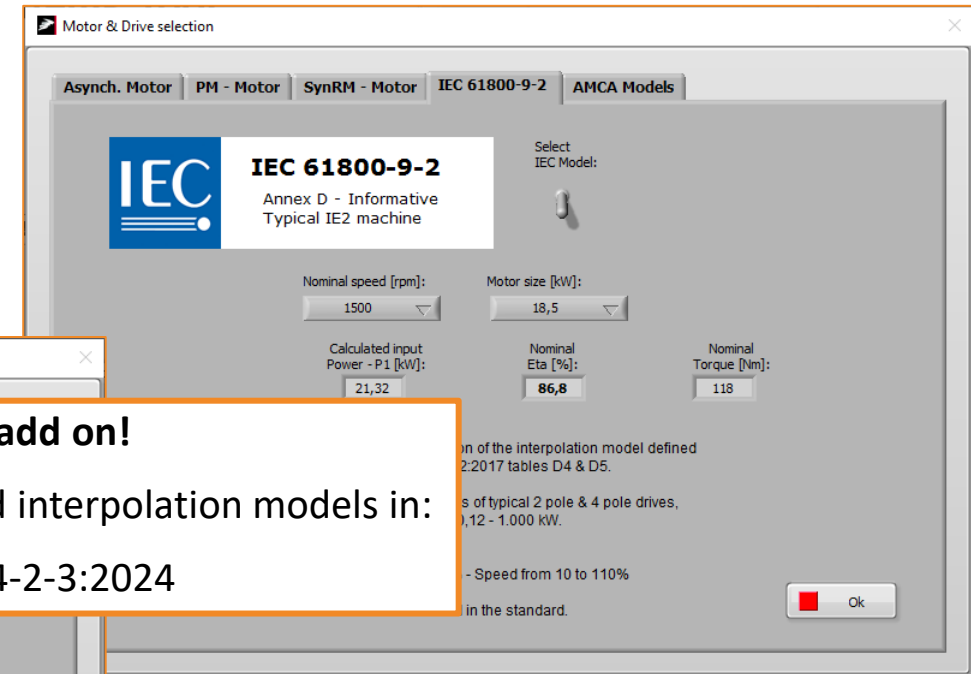
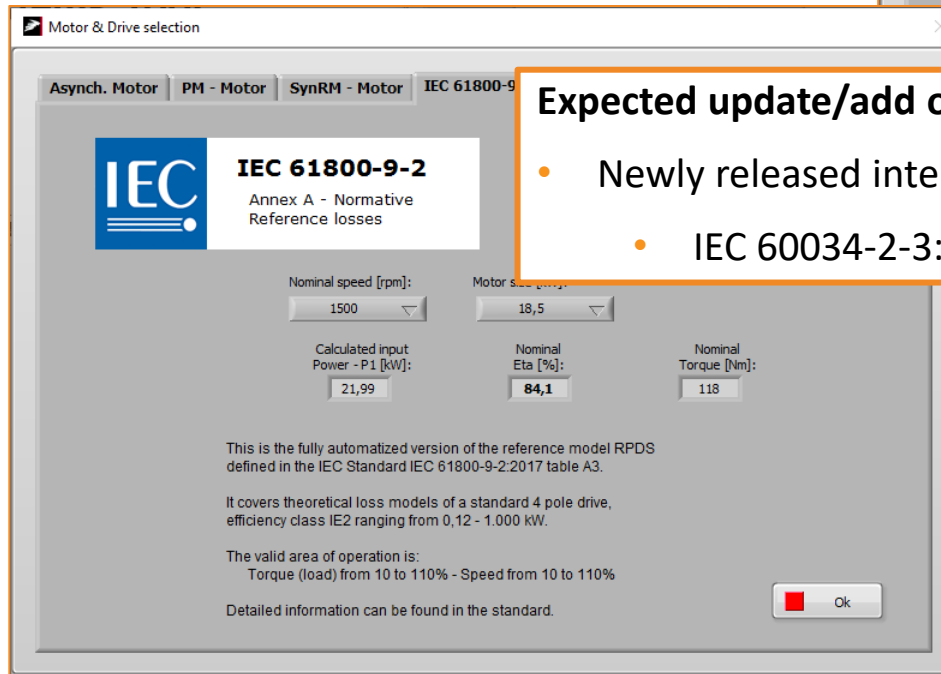
- Motor/Drive unit selection:
 - Loss models from IEC 61800-9-2
 - Annex A, Reference losses for Power Drive System (PDS)
 - 0.12 – 1.000 kW, 4 pole machines



- Annex D, “Typical” losses when driven by VSD
 - 0.12 – 1.000 kW, 2&4 pole machines, IE2

The Motor Systems Tool

- Motor/Drive unit selection:
 - Loss models from IEC 61800-9-2
 - Annex A, Reference losses for Power Drive System (PDS)
 - 0.12 – 1.000 kW, 4 pole machines



Expected update/add on!

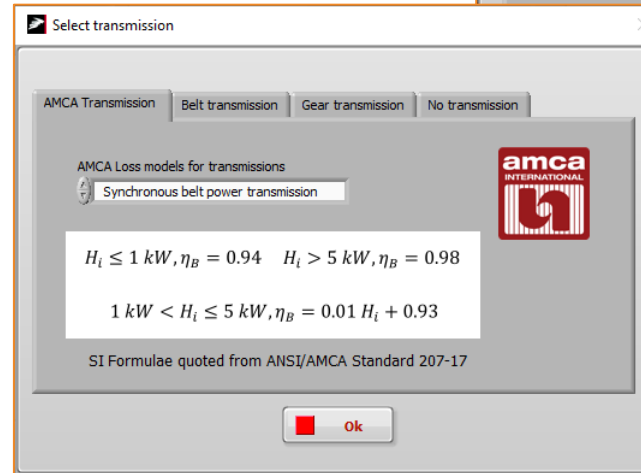
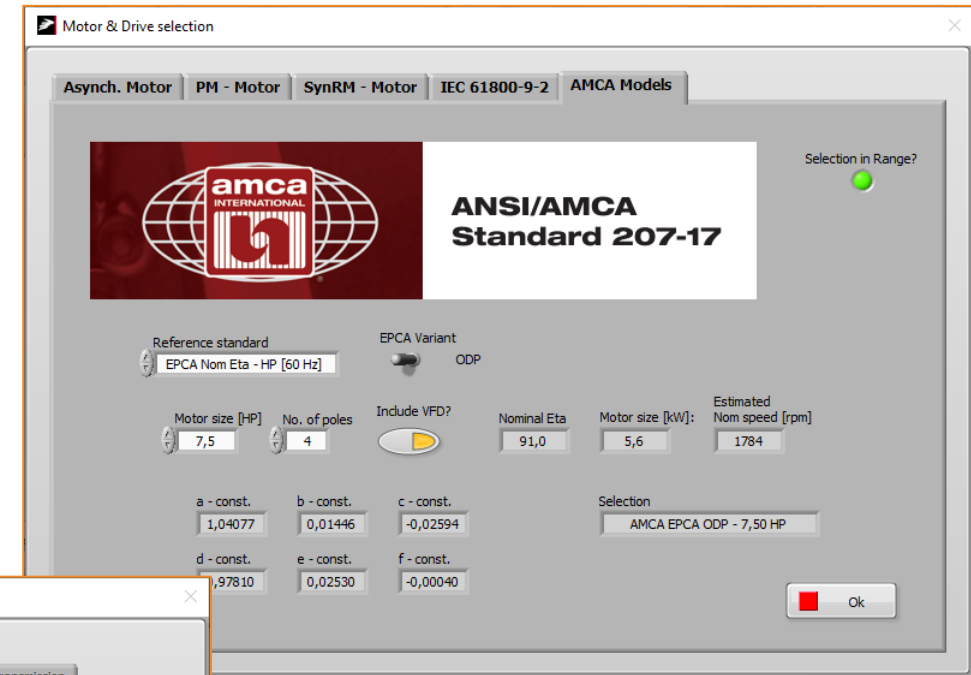
- Newly released interpolation models in:
 - IEC 60034-2-3:2024

- Annex D, “Typical” losses when driven by VSD
 - 0.12 – 1.000 kW, 2&4 pole machines, IE2

The Motor Systems Tool

- Motor/Drive unit selection:

- Loss models from AMCA 207-17
- AMCA models include:
 - EPCA nominal motors 60Hz (Hp)
 - EPCA nominal motors 60Hz (kW)
 - IEC 60034-30-1, 50Hz tables
 - IEC 60034-30-1, 60Hz tables
 - GB 18613 - 2012
- AMCA models also include:
 - 3 variants of belts



The Motor Systems Tool – Pump example

An example with a pump application

- An asynchronous motor with known nameplate
- No transmission
- Measurements available:
 - Flow, head & input power

The Motor Systems Tool – Pump example

Application Number / Name		P1								
Driven application	(Pump, Fan, Compr., Other)	Pump	Pump	Pump	Pump	Pump	Pump	Pump	Pump	Pump
Control method	(throttle/valve; on/off; hydraulic; VSD)	multiple valves (manual+control)	multiple valves (control)	valve	none	multiple valves (control)	multiple valves (control)	valve	none	none
Annual running hours	(hours/year)	4250	4250	4250	6570	4250	8500	8500	8000	8000
Duration curve *)	(PID; bell curve; 80%)	60-80%	? 80% control valve	100%	bell	bell	90%	100%	100%	100%
ATEX	(y/n)	n	n	n	n	n	n	n	n	n
Redundant	(y/n)	1oo2	1oo2	1oo2	3oo4	1oo2	n	n	n	n
Motor Power	(nameplate in kW)	90	45	110	315	37	22	11	160	160
Motor nominal speed	(rpm)	2970	2955	2900	1500	2950	2931	1460	1486	1486
Motor current	(A)	92	48	112	328	39,4	22,9	17,1	282	282
Motor cosphi		0,91 (full load)	0,89 (full load)	0,90 (full load)	0,87(full load)	0,89(full load)	0,91(full load)	0,84 (full load)	0,86 (full load)	0,86 (full load)
		0,91	0,89	0,9	0,87	0,89	0,91	0,84	0,86	0,86
Motor efficiency	(%)	95	93,5	94,8	96,7	92,8	92,1	88,3	96	96
Motor age [years, or year of built]	(years or year of built)	1998?	1998?	1998?	98/04?	1998?	2004?	1993?	2004?	2004?
Rewoundings	(y/n)									
Motor Voltage	(400V, 500V, 690V, other)	660V	660V	660V	660V	660V	660V	500V	600V	600V
Hot spot for improvement	(y/n, e.g. Maintenance)	running at low flow								
Number of similar applications	(#)	2 (=redundancy)	2 (=redundancy)	2 (=redundancy)	4 (=redundancy)	2 (=redundancy)	1	1	1	1

The Motor Systems Tool – Pump example

Application Number / Name		P1										
Driven application	(Pump, Fan, Compr., Other)	Pump										Pump
Control method	(throttle/valve; on/off; hydraulic; VSD)	multiple valves (manual+control)	multiple									none
Annual running hours	(hours/year)	4250										8000
Duration curve *)	(PID; bell curve; 80%)	60-80%										100%
ATEX	(y/n)	n										n
Redundant	(y/n)	1oo2										x nA II T3
Motor Power	(nameplate in kW)	90										n
Motor nominal speed	(rpm)	2970										160
Motor current	(A)	92										1486
Motor cosphi		0,91 (full load)	0,89 (f									282
		0,91										(full load)
Motor efficiency	(%)	95										0,86
Motor age [years, or year of built]	(years or year of built)	1998?										96
Rewoundings	(y/n)											2004?
Motor Voltage	(400V, 500V, 690V, other)	660V	660V	660V	660V	660V	660V	660V	500V	600V		
Hot spot for improvement	(y/n, e.g. Maintenance)	running at low flow										
Number of similar applications	(#)	2 (=redundancy)	2 (=redundancy)	2 (=redundancy)	4 (=redundancy)	2 (=redundancy)			1	1	1	

Motor & Drive selection

Asynch. Motor | **PM - Motor** | SynRM - Motor | IEC 61800-9-2 | AMCA Models

Input nameplate data:

Nominal Shaft Power: kW

Nominal Voltage: Volt

Nominal Current: Ampere

Nominal Cos phi: -

Nominal Frequency: Hz

Nominal Speed: rpm

Motor Size [kW]:

IE Class:

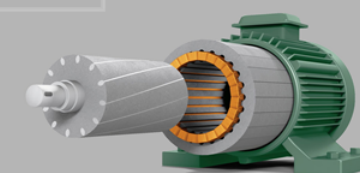
No. of Poles:

IEC 60034-30-1

Selected IEC Std. motor:

Calculated Torque [Nm]: Eta [%]:

Motor - 90,00 kW



The Motor Systems Tool – Pump example

- Inputs in MST-Tool:

P4 - Application calculator

Flow [m3/h]: 120 Head [m]: 141
Rho [kg/m3]: 998,2 g [m/s2]: 9,816

$P_{hyd} = Q \left[\frac{m^3}{s} \right] \cdot H [m] \cdot \rho \left[\frac{kg}{m^3} \right] \cdot g \left[\frac{m}{s^2} \right]$

Load profile A
12 fixed points

Input data

P4 - Load Output power [kW]: 46,05
New calculated Efficiency [%]: 59,64
P3 - Speed [rpm]: 2974
P3 - Load Input power [kW]: 77,22

OK

Transmission: P3 → P2

Motor: P2 → P1

P1 - Input Power [kW]: 82,0
Annual cost: 62.730,- Euro [€]
% Slip: 0,86

Total system efficiency [%]: 56,2

- Duty point:

- Input power, 82 kW
- Output power
 - 120 m3/h, 141 m head
- Running time 4.250h p.a.
- ≈ 348.5 MWh x 0.18€ = 62.730 €/p.a.

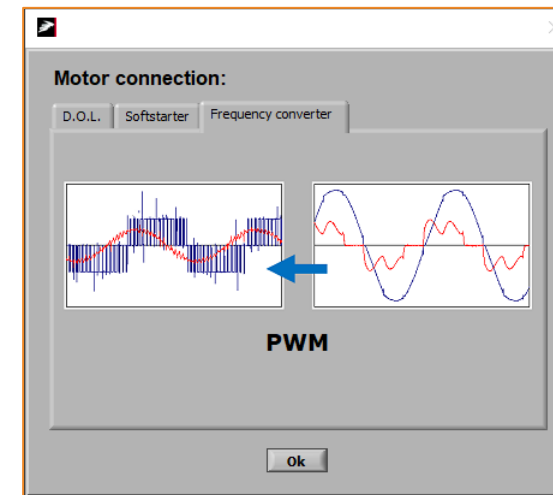
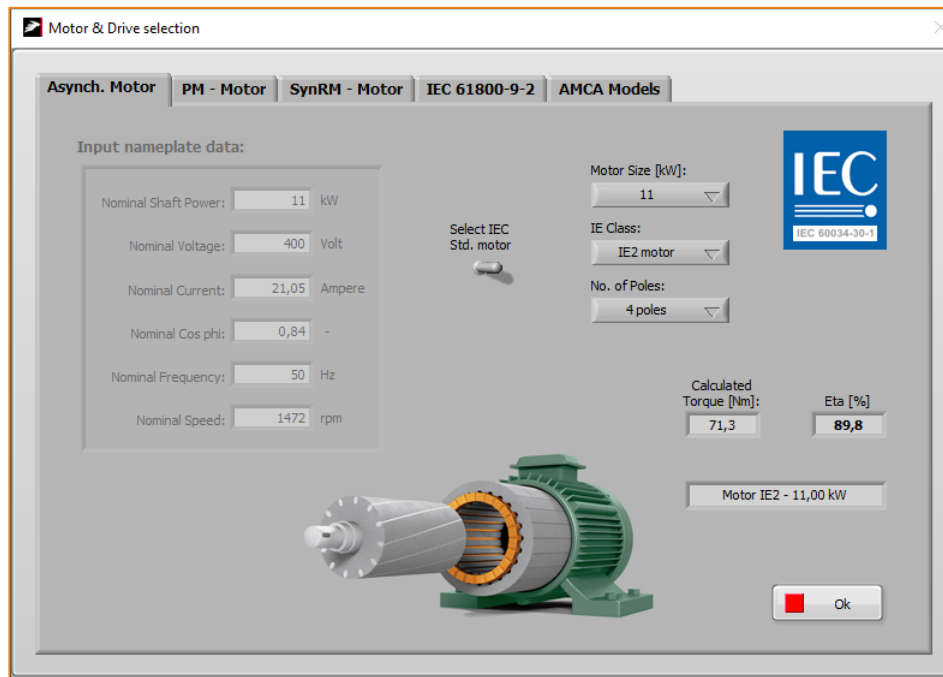
The Motor Systems Tool – 12 duty points

Another example, 12 points in application calculator

- A standard IE2 asynchronous motor with VSD
- No transmission
- Fan application with detailed curves available

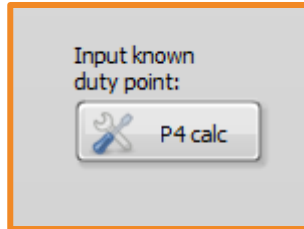
The Motor Systems Tool – 12 duty points

- Application calculator
 - Input of motor & VSD:



The Motor Systems Tool – 12 duty points

- Application calculator:



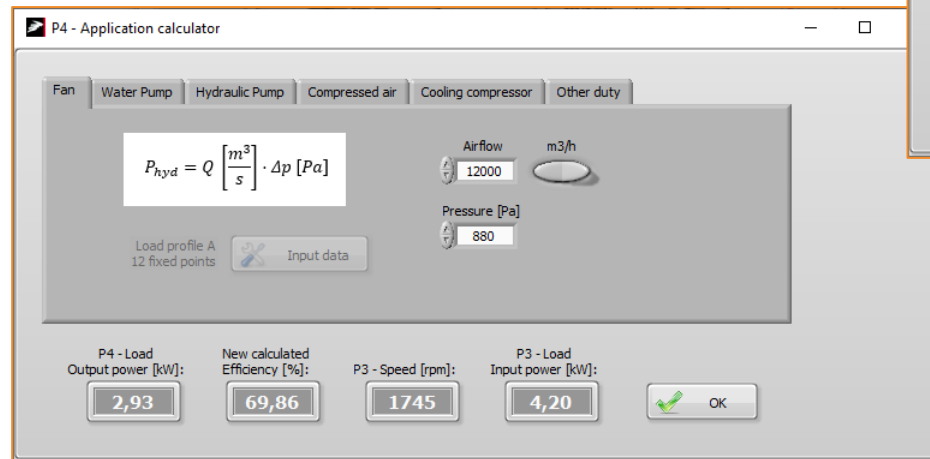
The screenshot shows the 'The MST-Tool by 4E EMSA' software interface. The main window is titled 'The MST-Tool by 4E EMSA' and has a version number of 4.23.05. The interface is divided into several sections:

- System overview:** Includes tabs for 'Before table', 'After table', 'Energy calculation', 'ECO-Design evaluation', and 'Evaluation of potential'.
- Load (P4):** Shows a pump and fan icon. The 'Calc. master' section has a green indicator light. The 'P4 - Load' section displays 'Output power [kW]: 7,15' and 'Input known duty point: P4 calc'.
- Transmission (P3):** Shows a red arrow icon. The 'Calc. master' section has a green indicator light. The 'P3 - Load' section displays 'Input power [kW]: 11,0', 'P3 Speed [rpm]: 1472', and 'P3 Torque [Nm]: 71,36'.
- Motor & Drive (P2):** Shows a motor icon with a PWM waveform. The 'Calc. master' section has a green indicator light. The 'P2 - Motor' section displays 'Shaft power [kW]: 11,0', 'P2 Speed [rpm]: 1472', and 'P2 Torque [Nm]: 71,36'.
- Motor & Drive (P1):** Shows a motor icon. The 'Calc. master' section has a green indicator light. The 'P1 - Input Power [kW]: 12,4' and 'Annual cost: 19.607,- Euro [€]'.

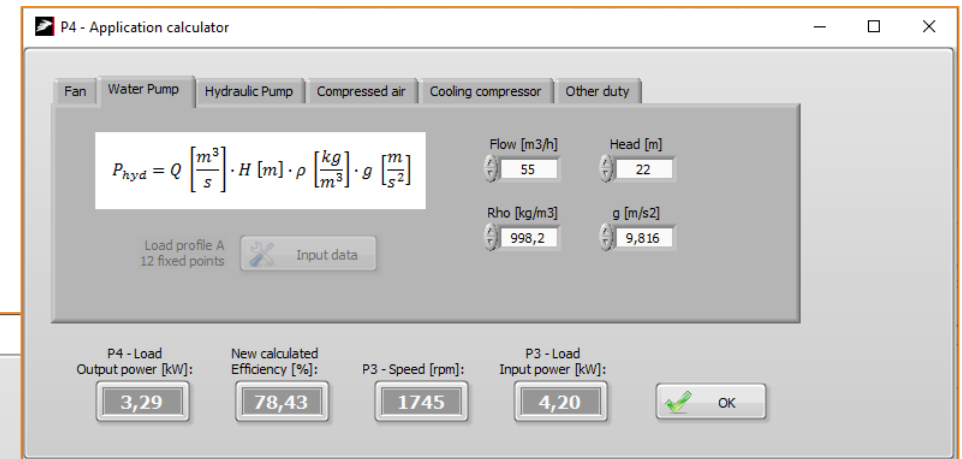
At the bottom, there is a 'Total system efficiency [%]' section showing a value of 57,5 and a color-coded bar. The interface also includes buttons for 'HTML Output', 'Load', 'Save', 'Reset', and 'Stop', and the logo for 'DANISH TECHNOLOGICAL INSTITUTE'.

The Motor Systems Tool – 12 duty points

- Application calculator:
 - Includes standardized models for:
 - Pump, Fan, Hydraulic pump
Air,- & Cooling compressors



Fan input page



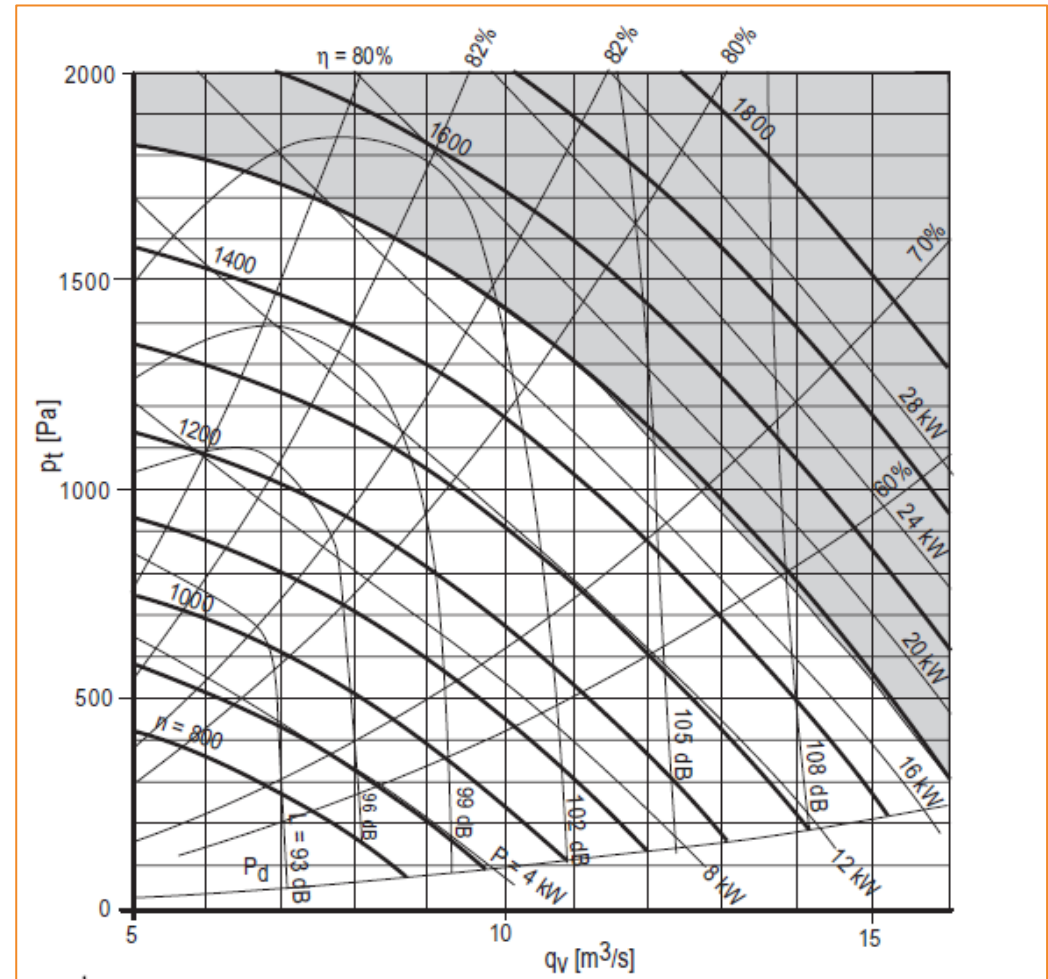
Pump input page

The Motor Systems Tool – 12 duty points

- Application calculator:
 - Includes standardized models for:
 - Pump, Fan, Hydraulic pump
 - Air,- & Cooling compressors

For the “opposite direction” of calculation, both pump & fan have the possibility to input the pump/fan curve for automatic calculation of duty point.

Fan example:

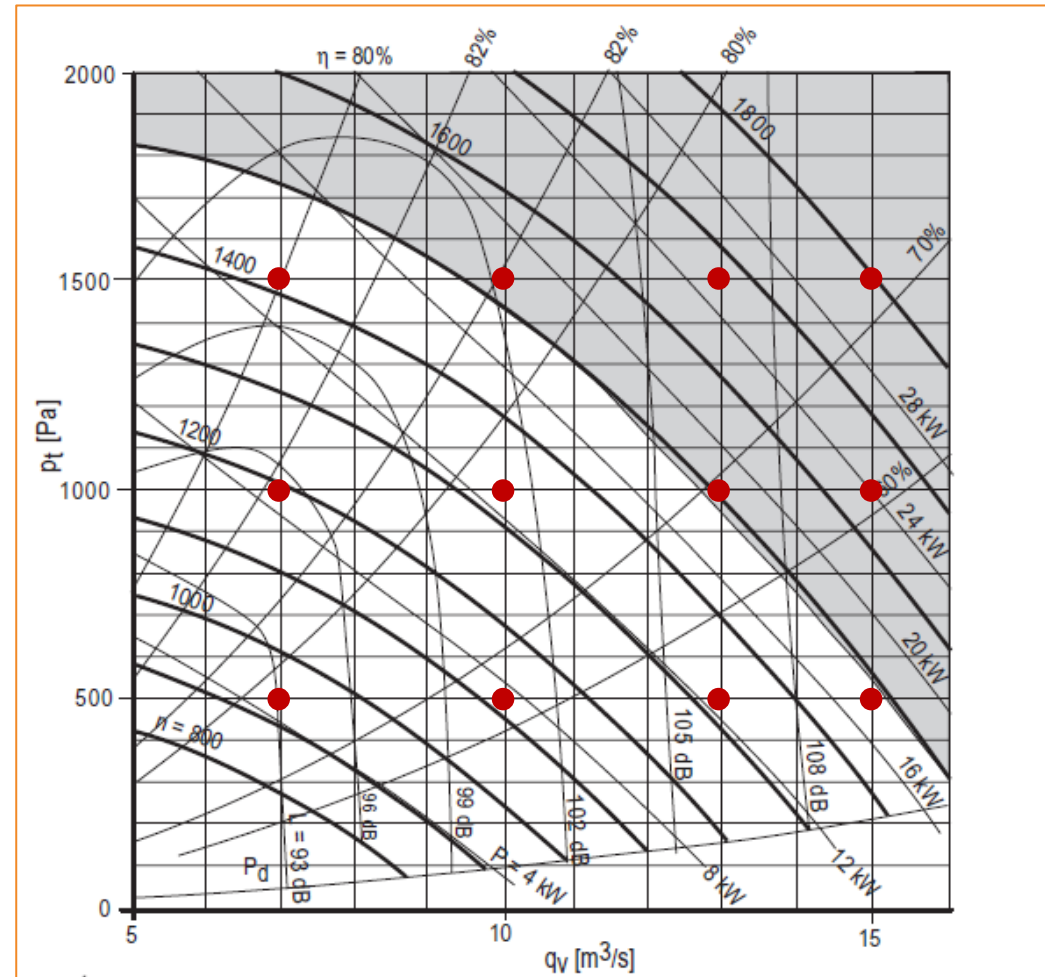


The Motor Systems Tool – 12 duty points

- Application calculator:
 - Includes standardized models for:
 - Pump, Fan, Hydraulic pump
 - Air,- & Cooling compressors

For the “opposite direction” of calculation, both pump & fan have the possibility to input the pump/fan curve for automatic calculation of duty point.

Definition of 12 representative duty points:



The Motor Systems Tool – 12 duty points

- Application calculator:

Included

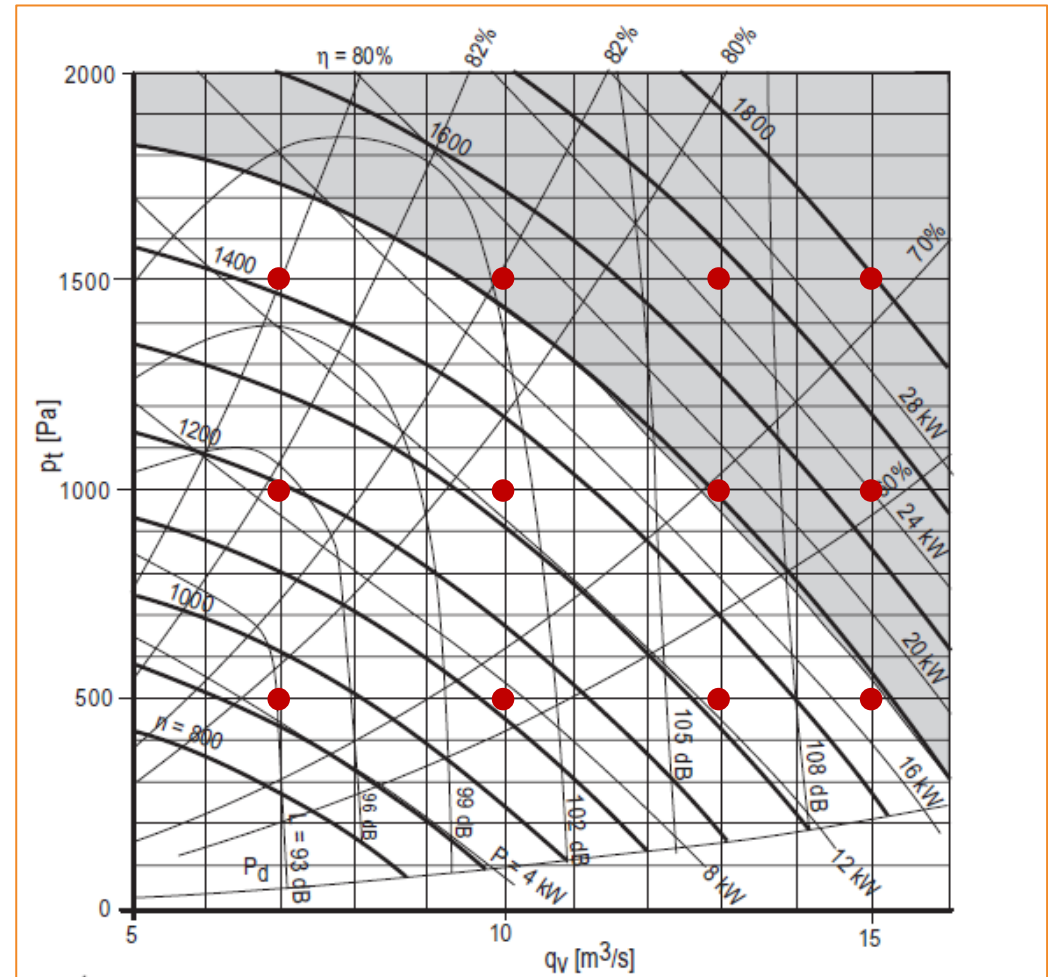
Input 12 known duty points:

	Par. A	Par. B	Speed	Eta
01	7	500	930	78
02	7	1000	1190	82
03	7	1500	1420	80
04	10	500	1130	65
05	10	1000	1340	77
06	10	1500	1535	81,5
07	13	500	1330	57
08	13	1000	1515	69
09	13	1500	1680	76
10	15	500	1475	54
11	15	1000	1645	62
12	15	1500	1800	72

Buttons: Open file, Save file, Clear table

12 duty points ok? █

Buttons: OK, Cancel

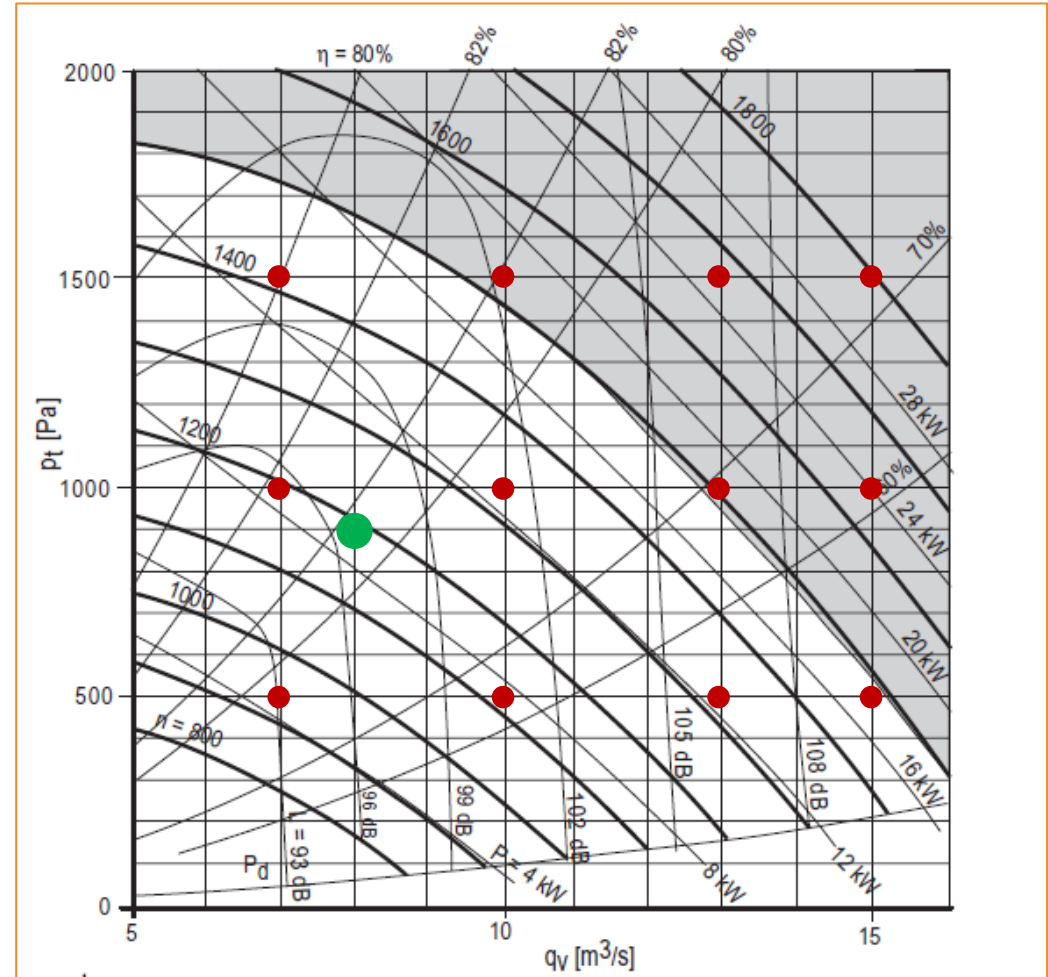


The Motor Systems Tool – 12 duty points

- Application calculator:
 - Includes standardized models for:
 - Pump, Fan, Hydraulic pump
 - Air,- & Cooling compressors

For the “opposite direction” of calculation, both pump & fan have the possibility to input the pump/fan curve for automatic calculation of duty point.

Specific duty point (8 m³/s, 900 pa):



The Motor Systems Tool – 12 duty points

P4 - Application calculator

Fan Water Pump Hydraulic Pump Compressed air Cooling compressor Other duty

$$P_{hyd} = Q \left[\frac{m^3}{s} \right] \cdot \Delta p [Pa]$$

Airflow m^3/s : 8

Pressure [Pa]: 900

Load profile A
12 fixed points

Input data

P4 - Load Output power [kW]: 7,20

New calculated Efficiency [%]: 81,36

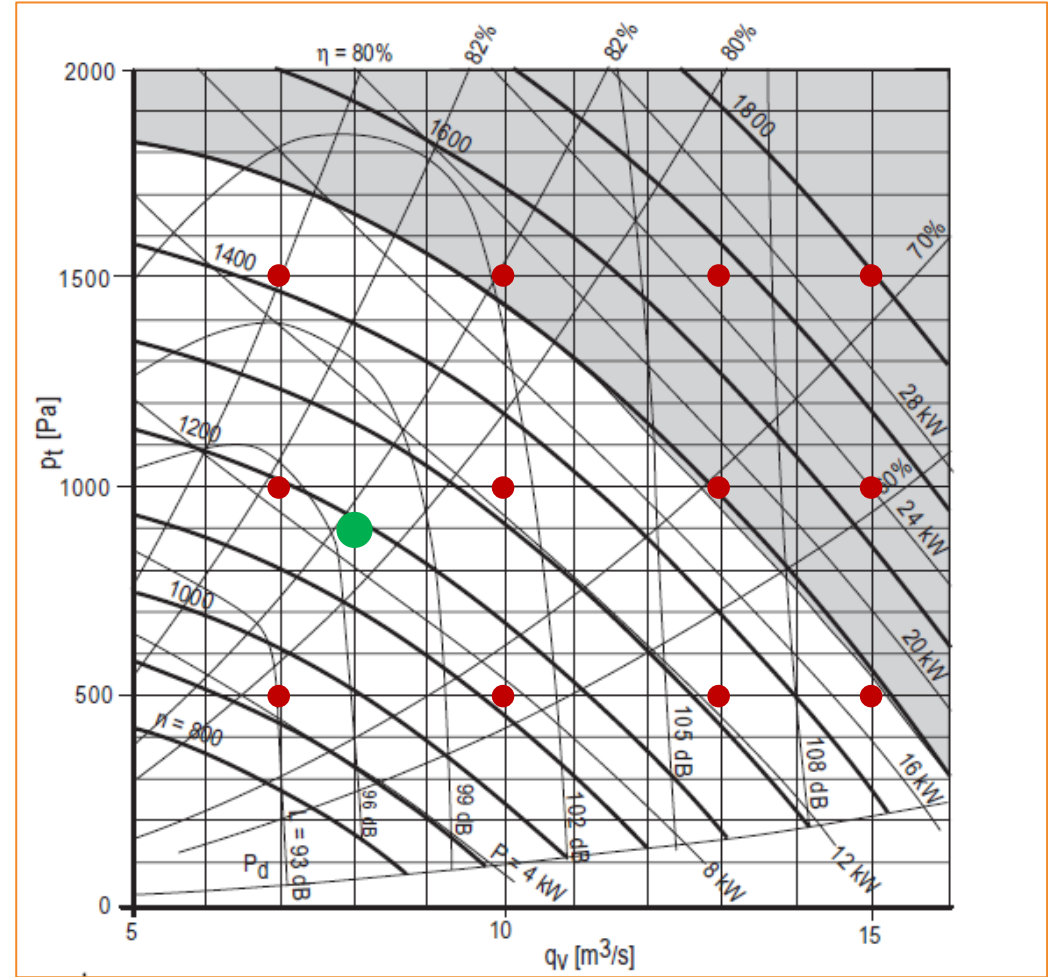
P3 - Speed [rpm]: 1183

P3 - Load Input power [kW]: 8,85

Use load profile: ON

OK

Specific duty point (8 m³/s, 900 pa):



The Motor Systems Tool – 12 duty points

- Application calculator:
 - Complete system calculated:



The Motor Systems Tool

- The Motor Systems Tool, MST-Tool
 - A dynamic tool under continuous development
 - Published ecodesign regulation on fans
 - Upcoming ecodesign regulation on pumps
 - Interpolation / extrapolation models from IEC 60034-2-3:2024
 - A part of a family of tools calculating:
 - Air compressors, Vacuum systems, Hydraulic systems and soon Ventilation systems
- Find 4E EMSA Tools at: <https://www.iea-4e.org/emsa/>
 - Updated versions of tools soon to be released!
 - Including updated guide, examples etc.
- Hotline (Hotmail) for MST: mst@iea-4e.org

The Motor Systems Tool

- Sign up for our newsletter

Technology Collaboration Programme by IEA

4E Electric Motor Systems Platform EMSA

News Publications Our Work About

News

4E Home » Electric Motor Systems » News

Need help with the Motor Systems Tool?
SEPTEMBER 9, 2024
Check out our freshly updated Quick guide!
[READ MORE](#)

Webinar upcoming on EMSA's Motor Systems Tool
SEPTEMBER 9, 2024
Sandie B. Nielsen, the developer of the Motor Systems Tool will hold a webinar on 10 September 3 PM CEST to show the Tool to interested users. A great opportunity to try the Tool and ask questions from its developer!
[READ MORE](#)

Digitalisation in motor systems – what value does it bring?
AUGUST 13, 2024
EMSA just released a new Policy Brief, summarising the key findings of four recent EMSA publications on digitalisation in electric motor systems. These explain in detail the benefits of digitalisation.
[READ MORE](#)

Search ...

SUBSCRIBE TO OUR NEWSLETTER

The Motor Systems Tool

Thank you for listening



**DANISH
TECHNOLOGICAL
INSTITUTE**

Sandie B. Nielsen

Representing Denmark in 4E EMSA

Danish Technological Institute

sbn@dti.dk