Energy Efficient End-use Equipment
International Energy Agency

Electric Motor Systems
EMSA

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

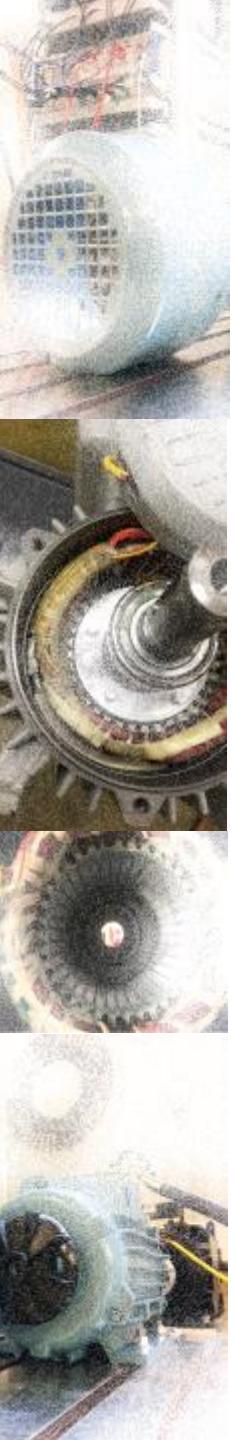
- **Sandie B. Nielsen** (sbn@dti.dk)
  - Danish Technological Institute (http://dti.dk)
- Electrical Engineer – Motor & Drives specialist, programmer
- Employments:
  - 1996-2001 – ABB (Drives specialist)
  - 2001-2002 – DEFU (Project manager, energy optimization)
  - 2002- present – Danish Technological 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



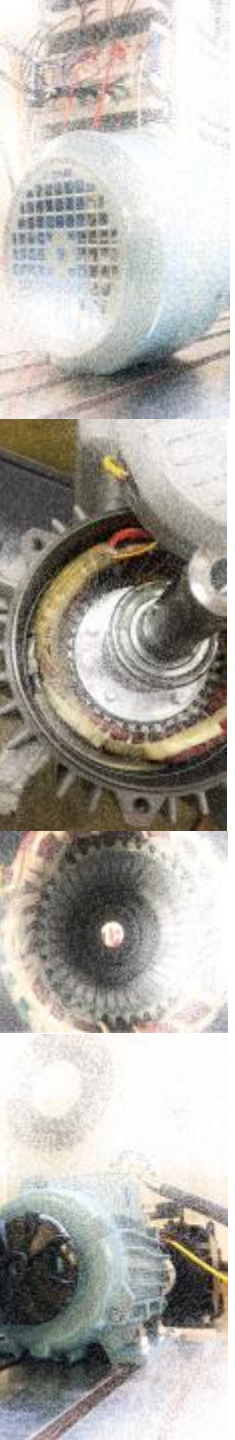
The Motor Systems Tool

- 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

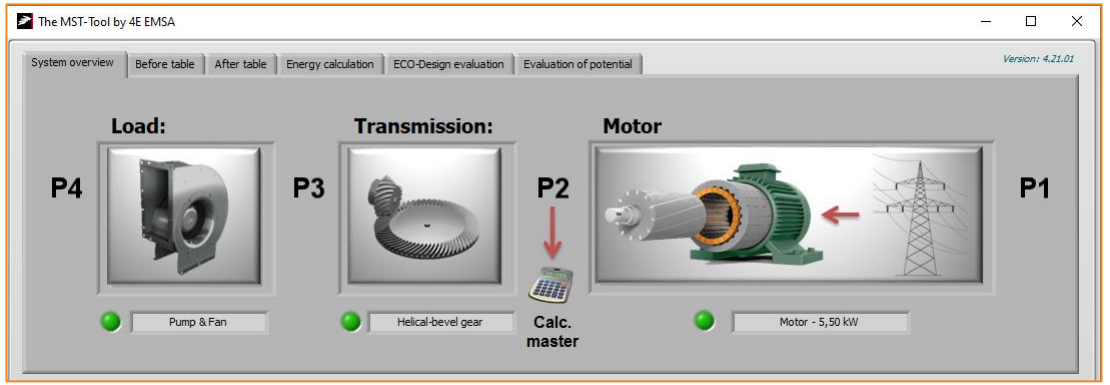
Today, more than 12 years later we have registered more than 4.500 unique downloads!



The Motor Systems Tool

- Basic function:

Selection of three essential components:

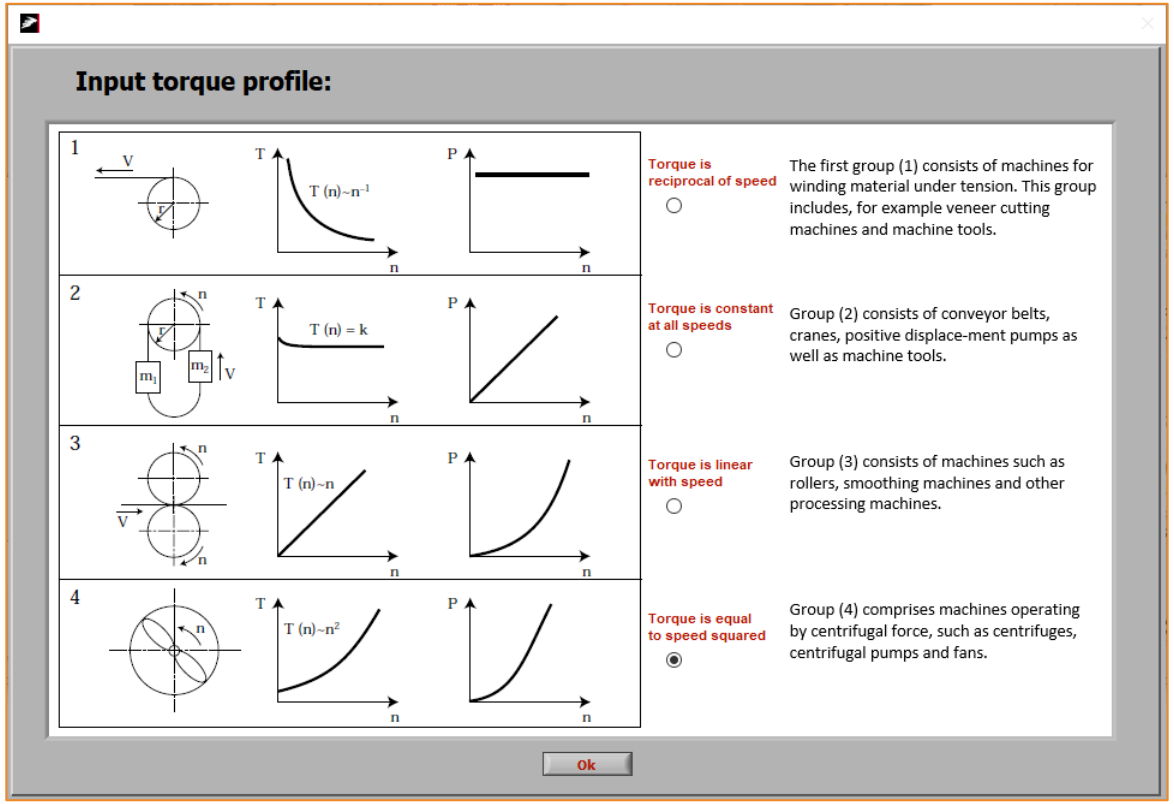


Load Transmission Motor/Drive unit

Electric Motor Systems EMSA

The Motor Systems Tool

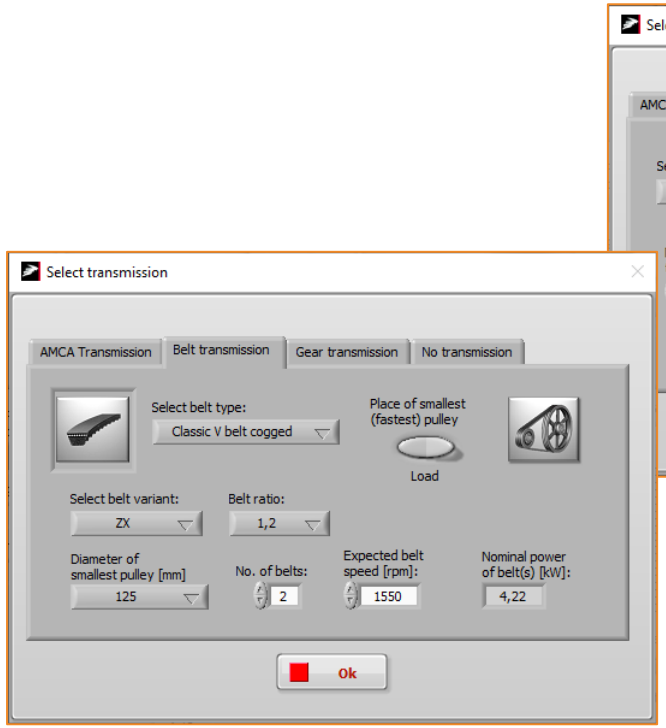
- Load profile:



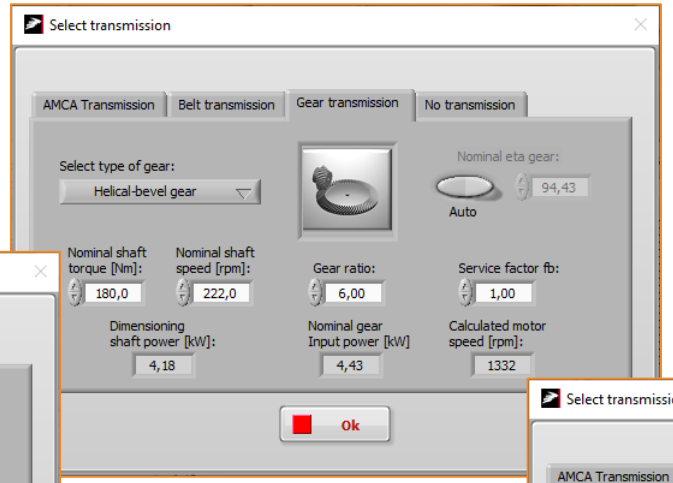
Electric Motor Systems EMSA

The Motor Systems Tool

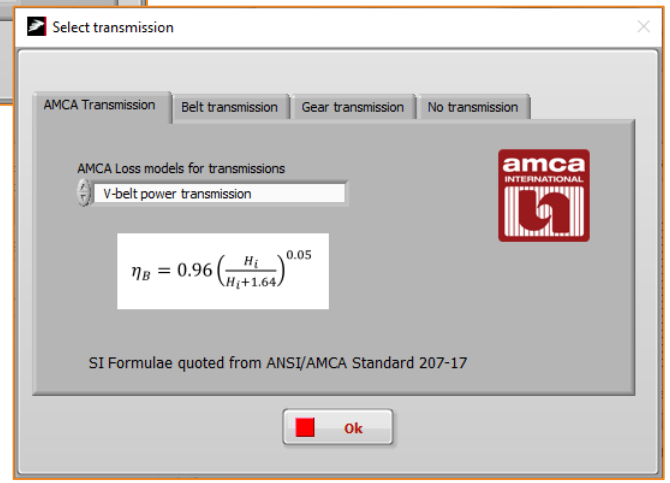
- Transmission:



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



Worm gear
Bevel gear or
Helical gear

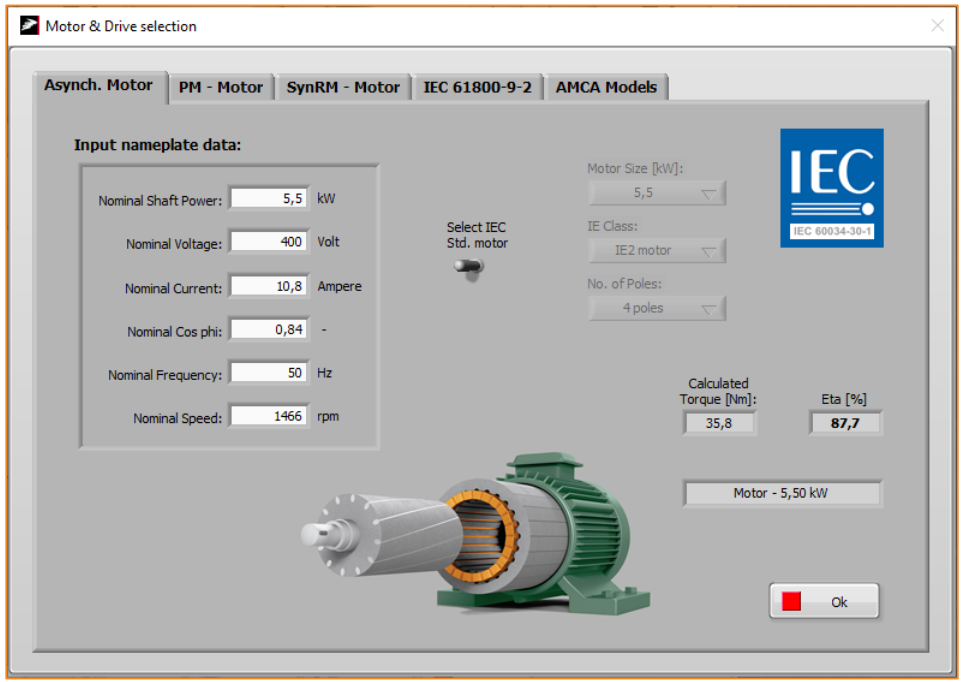


AMCA models for transmission

Electric Motor Systems EMSA

The Motor Systems Tool

- Motor/Drive unit selection:

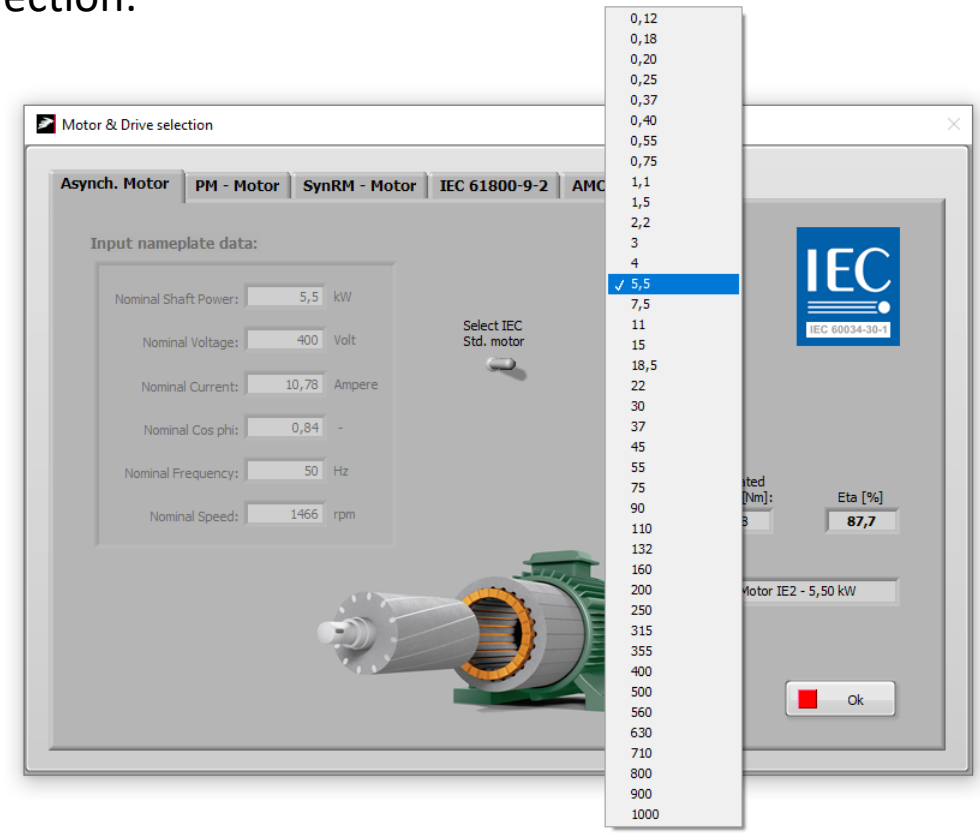


Asynchronous motor – 5.5 kW from nameplate

Electric Motor Systems EMSA

The Motor Systems Tool

- Motor/Drive unit selection:

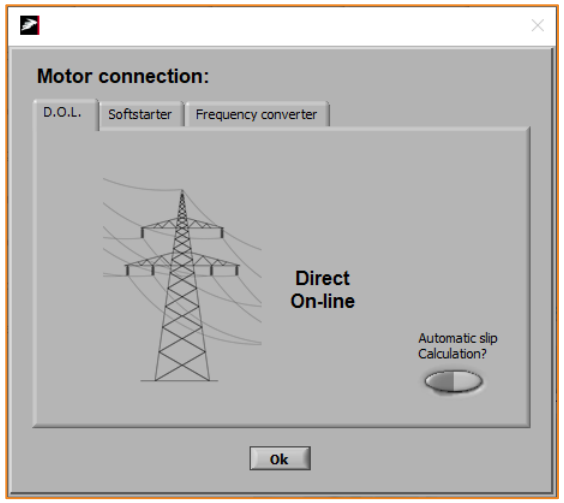


Asynchronous motor – 5.5 kW from IEC 60034-30-1 Tables

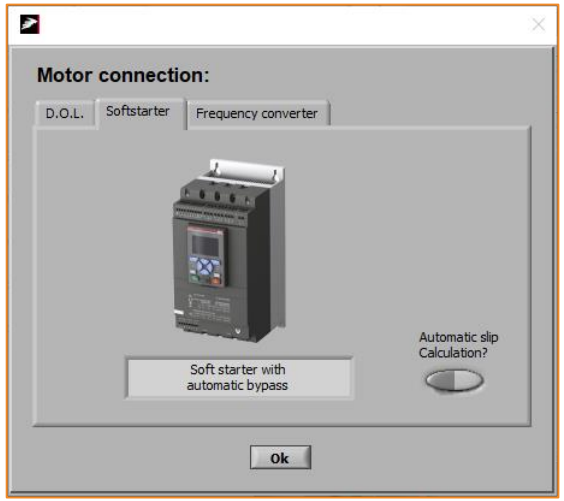
Electric Motor Systems EMSA

The Motor Systems Tool

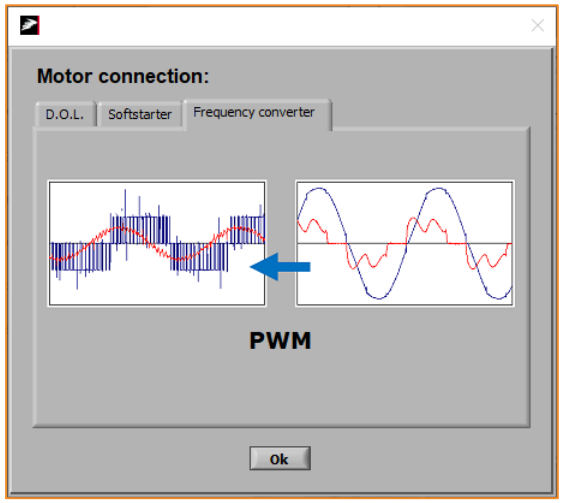
- Motor/Drive unit selection:



Direct On-line



Soft starter

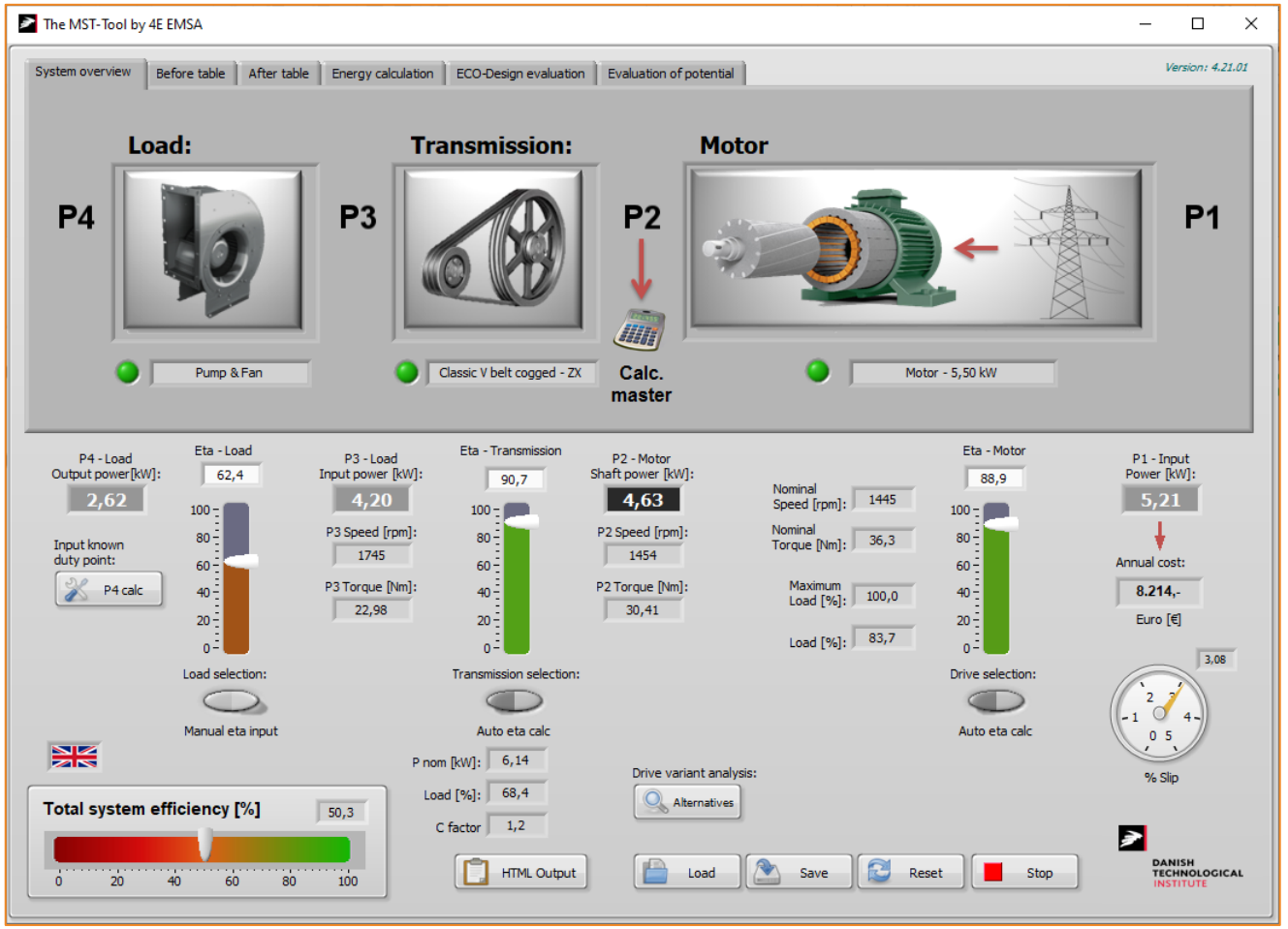


Frequency Converter

Electric Motor Systems EMSA

The Motor Systems Tool

- Main window:

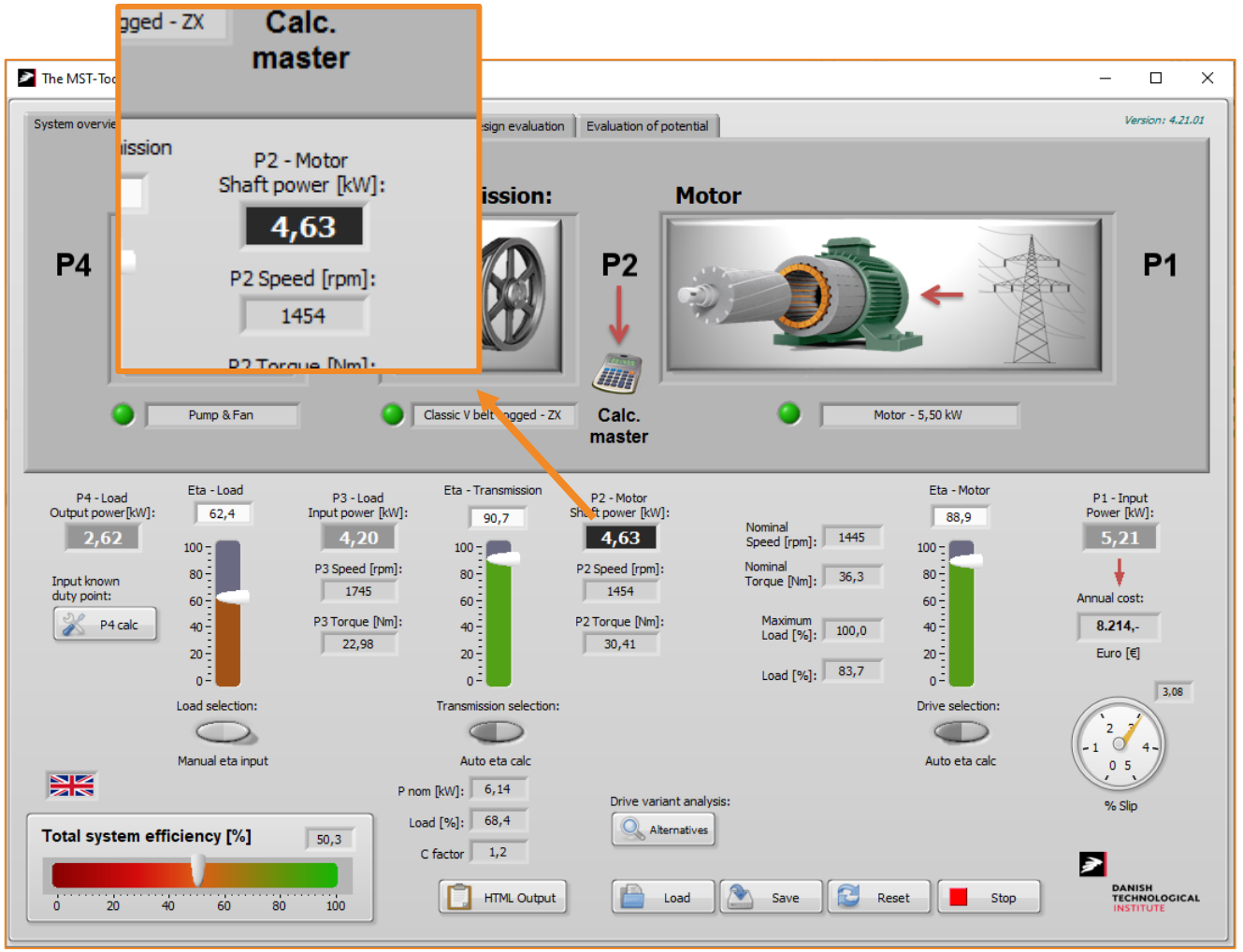


Electric Motor Systems EMSA

The Motor Systems Tool

- Main window:

Dynamic duty point selection

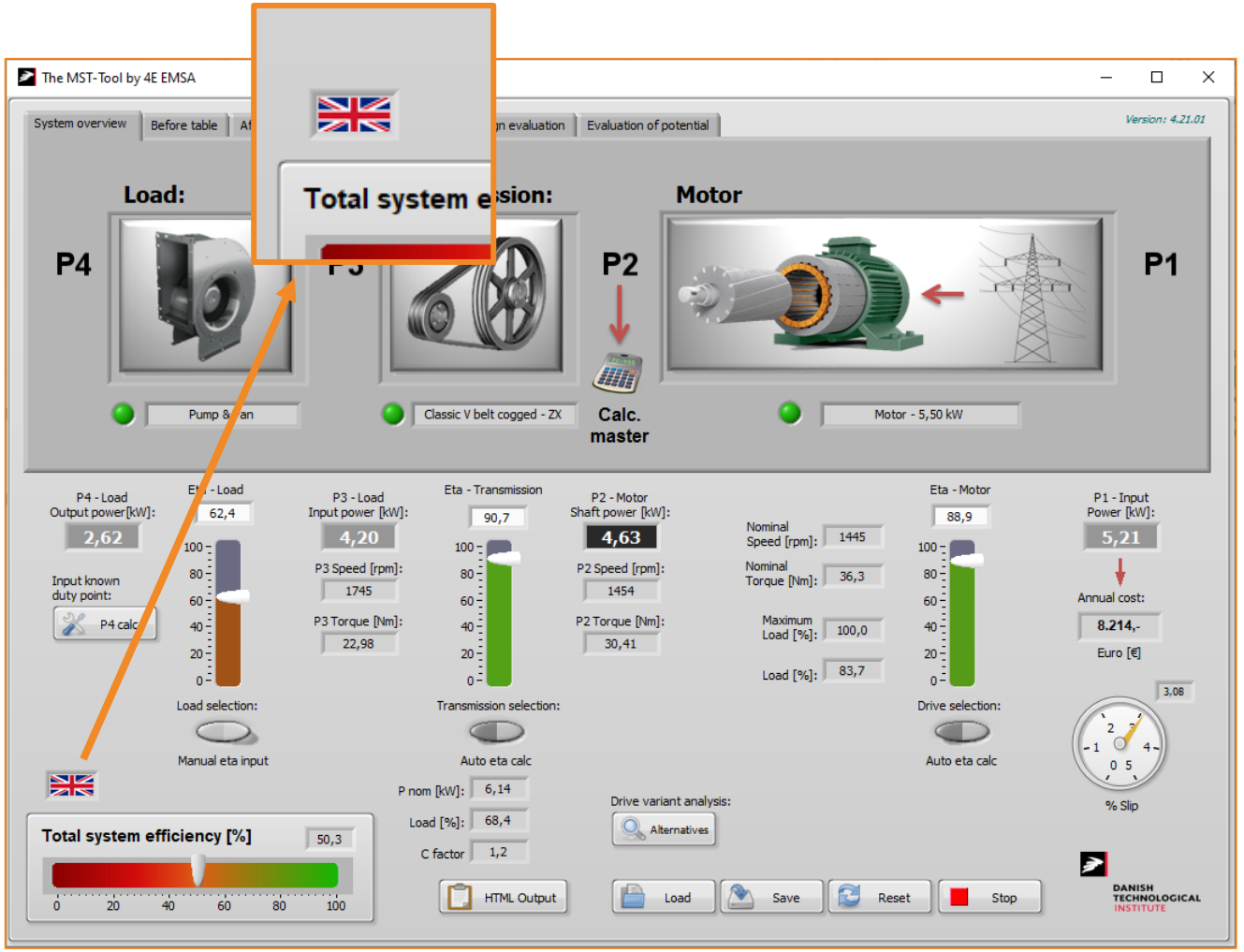


Electric Motor Systems EMSA

The Motor Systems Tool

Dynamic language selection, switch “On the fly”

- Main window:



Electric Motor Systems EMSA

The Motor Systems Tool

- Main window:

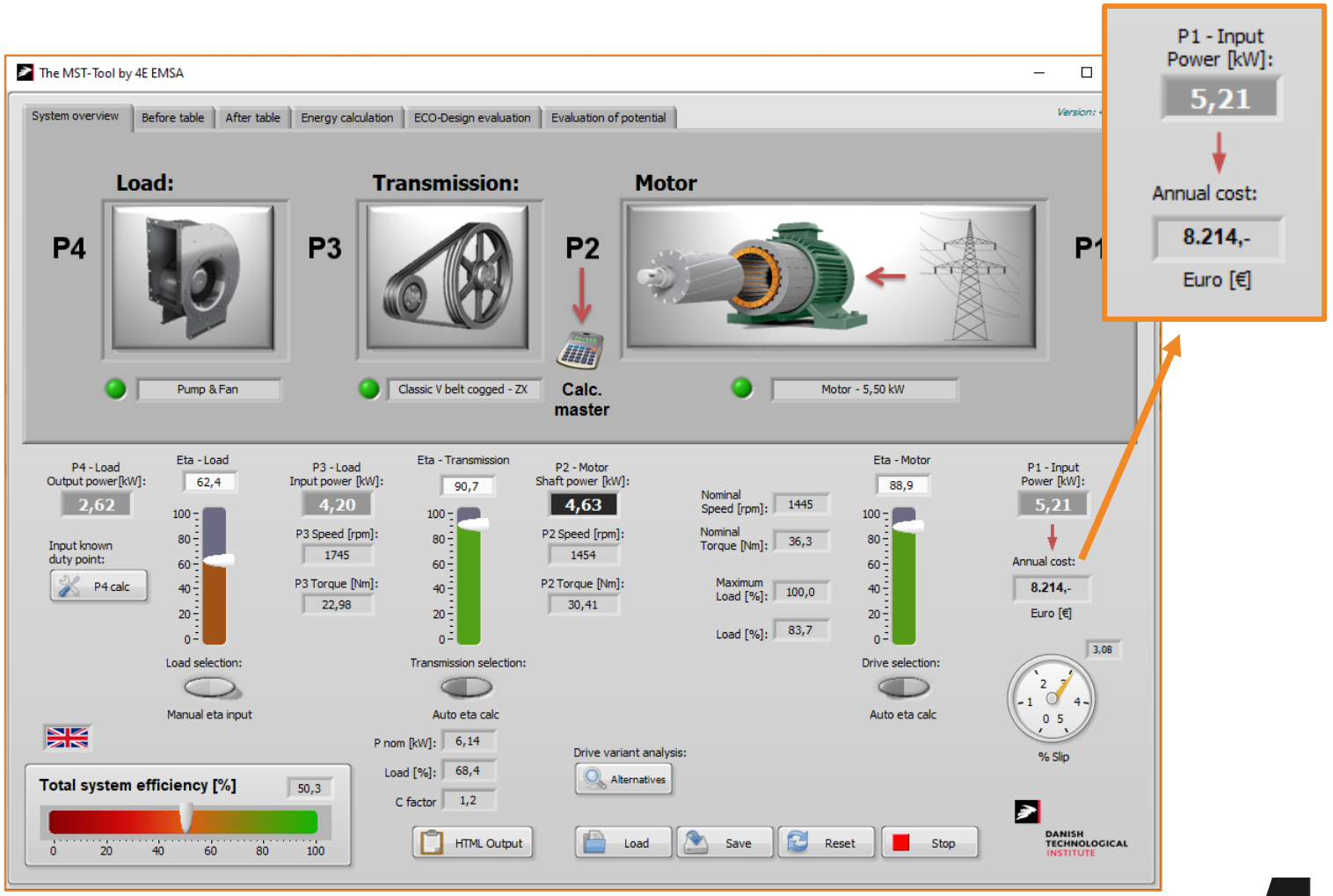
Automatic slip calculator (D.O.L. machines)

Electric Motor Systems EMSA

The Motor Systems Tool

- Main window:

Annual cost – on the fly

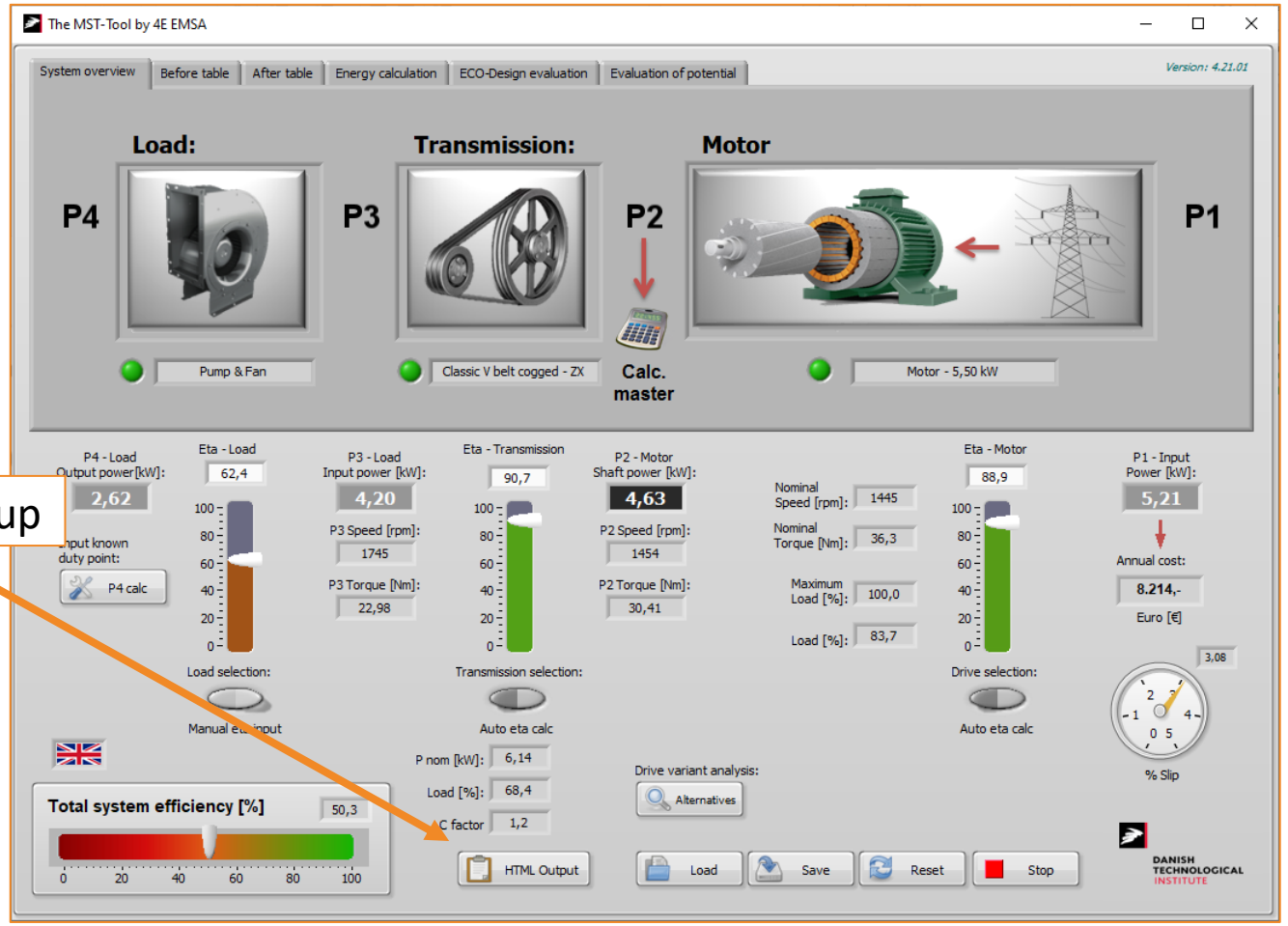


P1 - Input Power [kW]:
5,21
Annual cost:
8.214,-
Euro [€]

Electric Motor Systems EMSA

The Motor Systems Tool

- Main window:



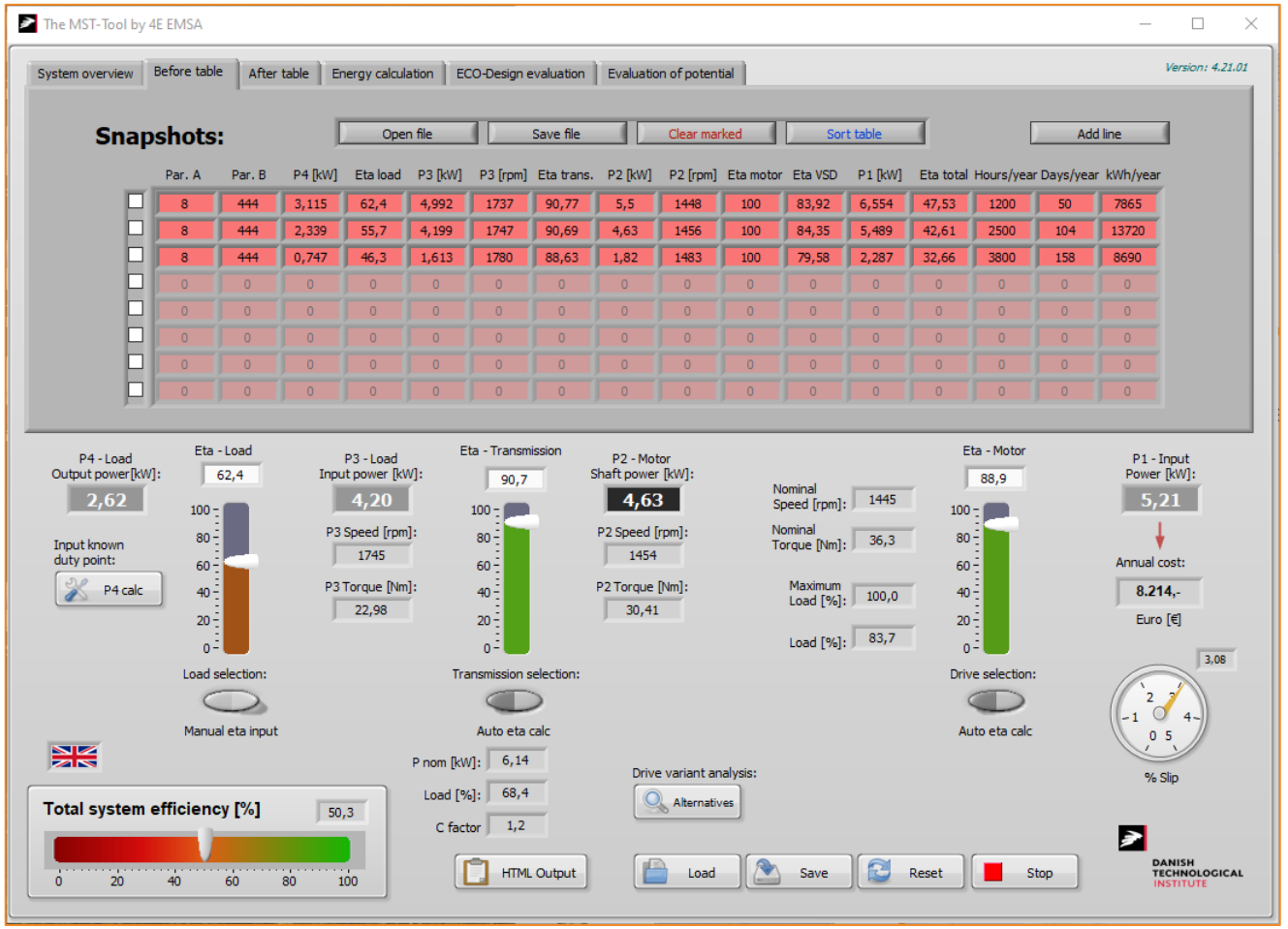
Visual save of setup

Electric Motor Systems EMSA

The Motor Systems Tool

Save duty points – Before situation

- Main window:

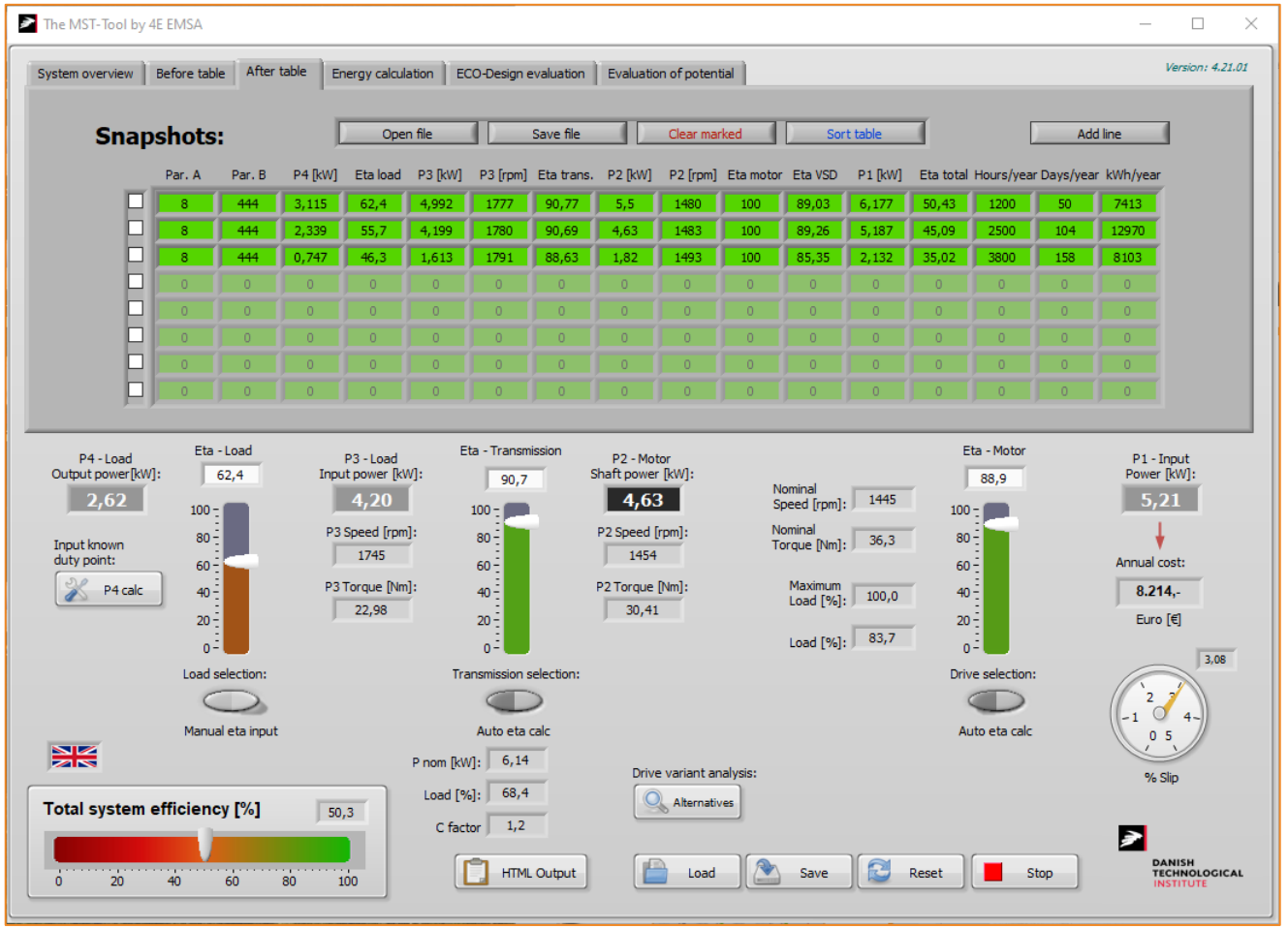


Electric Motor Systems EMSA

The Motor Systems Tool

Save duty points – After situation

- Main window:

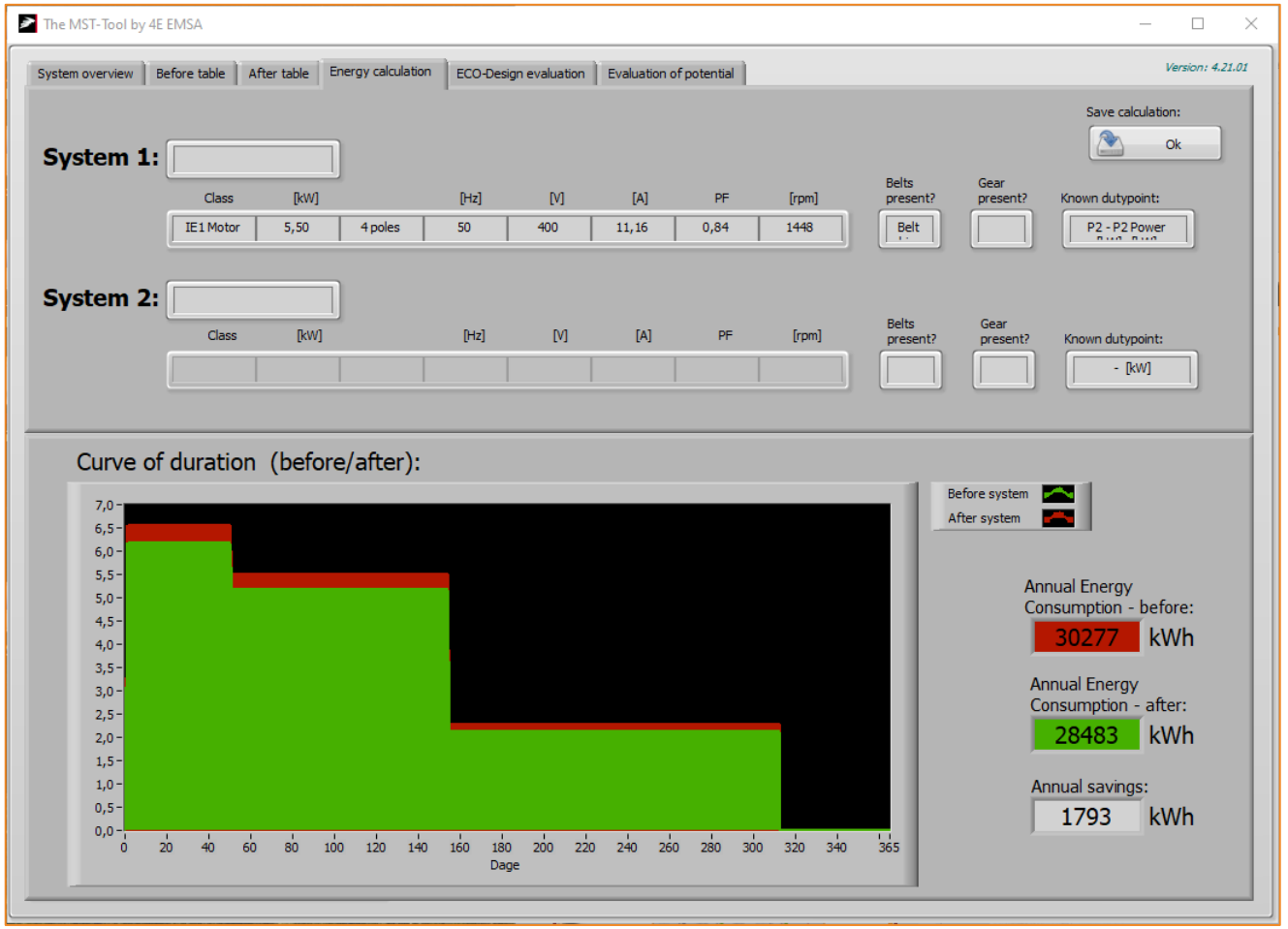


Electric Motor Systems EMSA

The Motor Systems Tool

Instant savings calculated

- Main window:

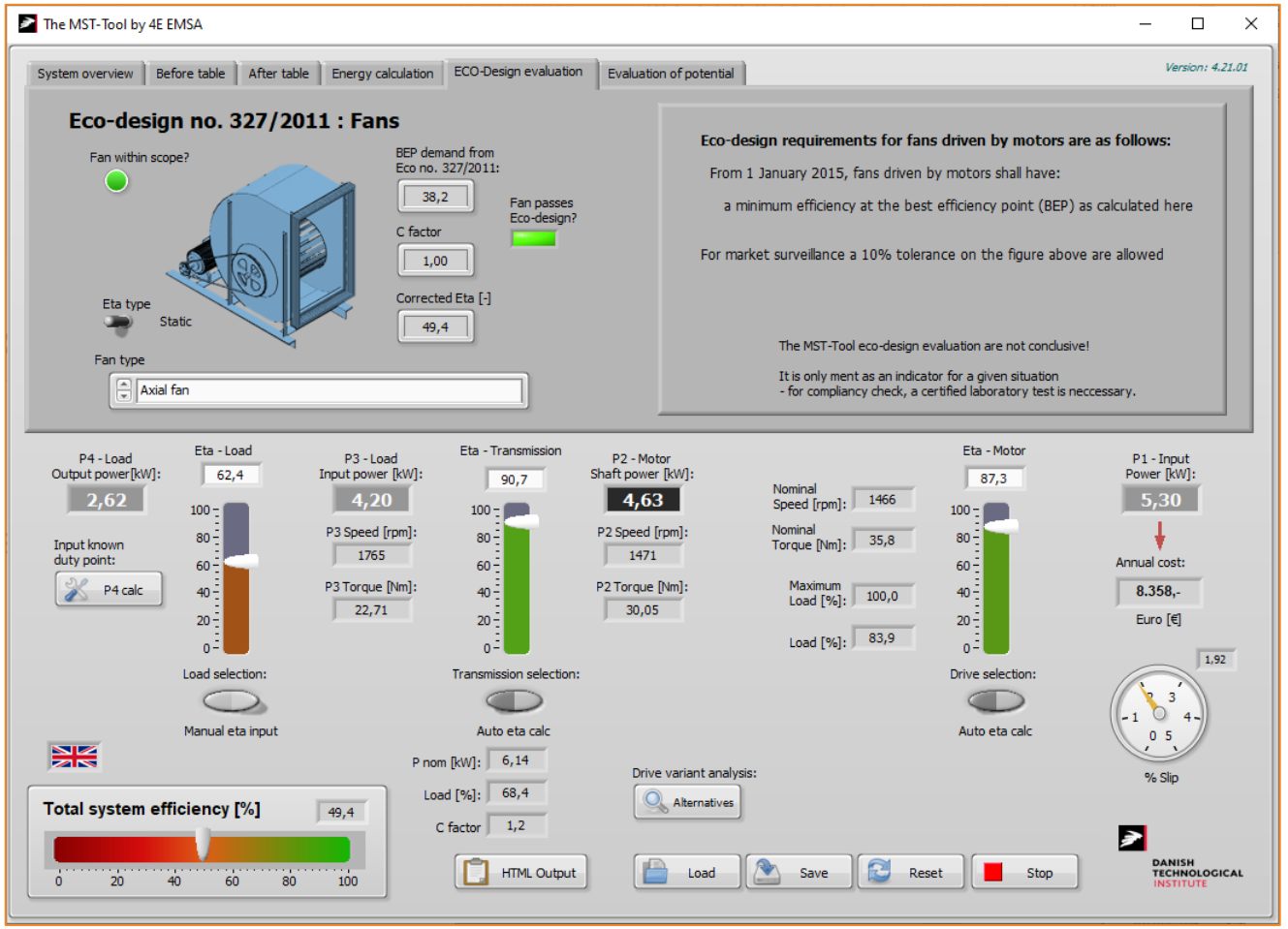


Electric Motor Systems EMSA

The Motor Systems Tool

Evaluation for European ecodesign, Fans

- Main window:

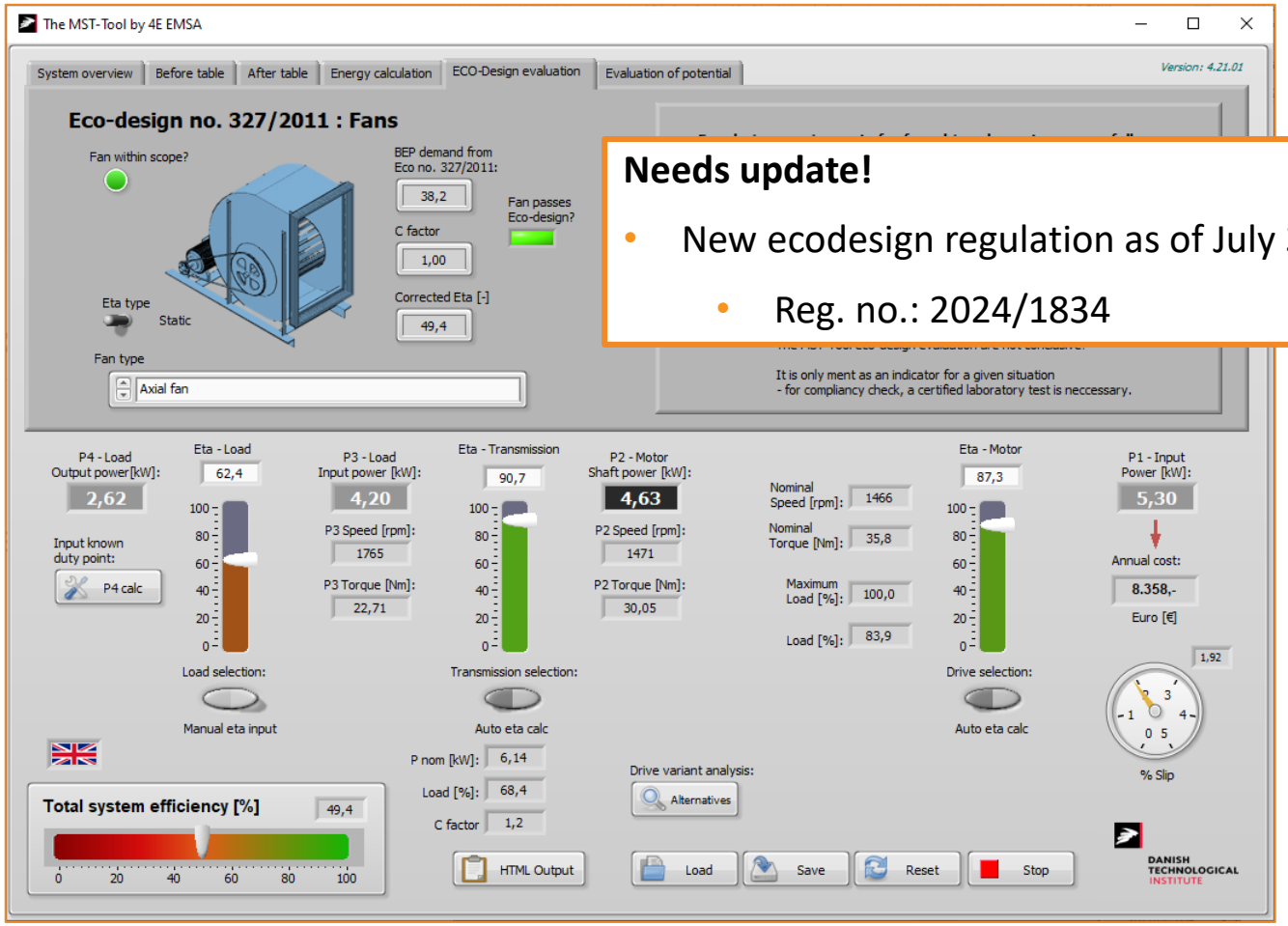


Electric Motor Systems EMSA

The Motor Systems Tool

Evaluation for European ecodesign, Fans

- Main window:



Needs update!

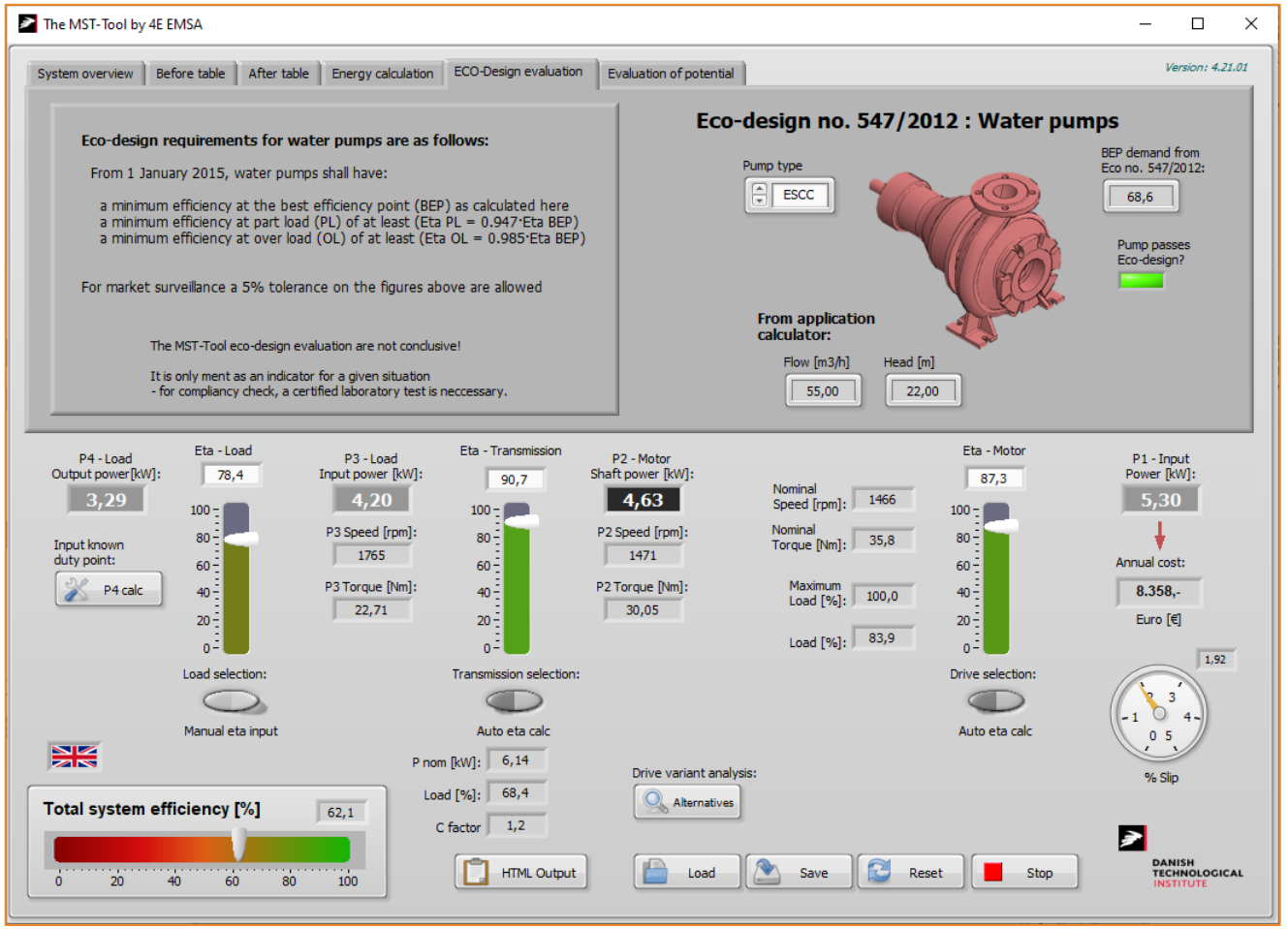
- New ecodesign regulation as of July 3rd, 2024
  - Reg. no.: 2024/1834

Electric Motor Systems EMSA

The Motor Systems Tool

- Main window:

Evaluation for European ecodesign, Pumps

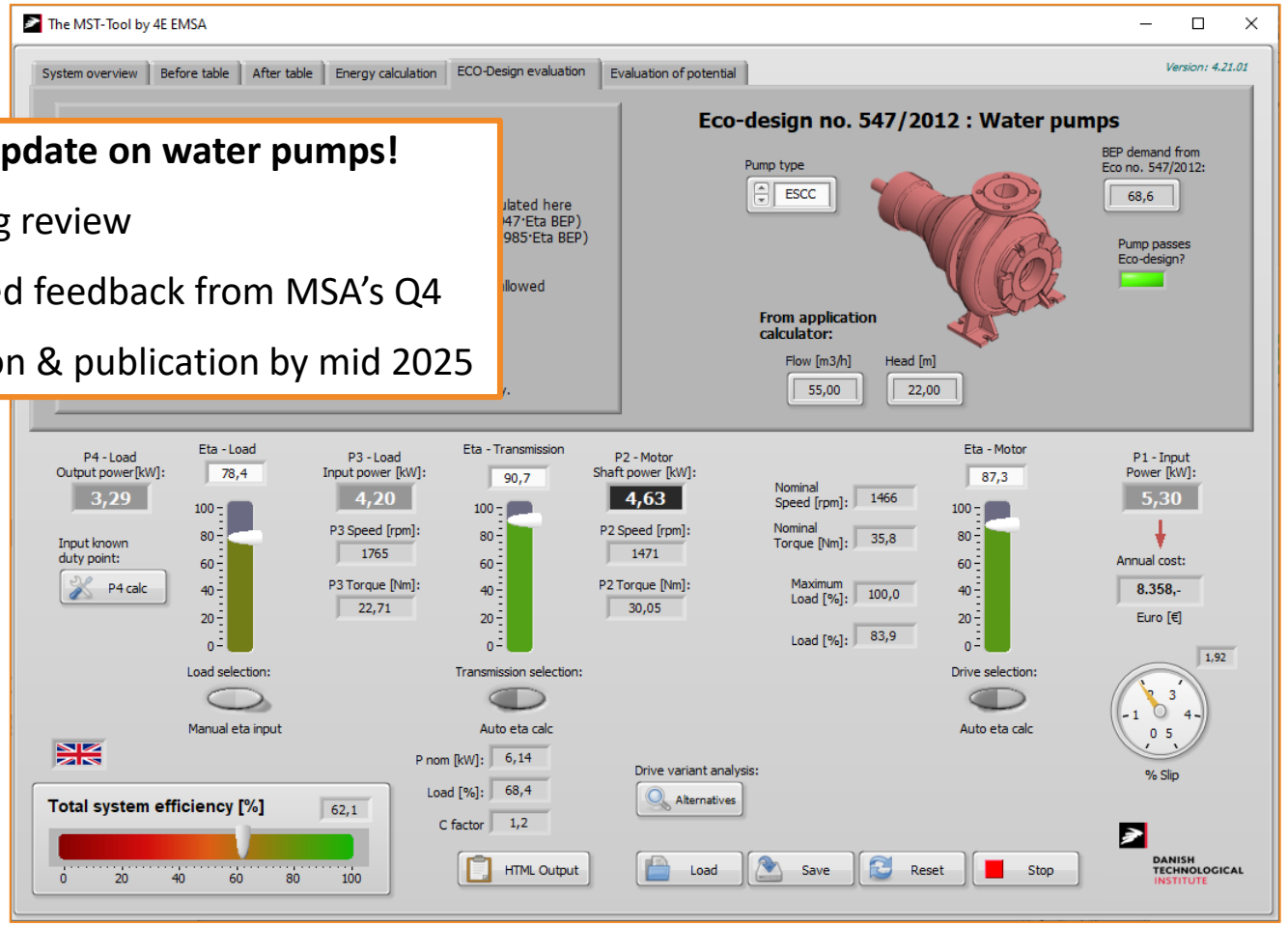


Electric Motor Systems EMSA

The Motor Systems Tool

Evaluation for European ecodesign, Pumps

- Main window:



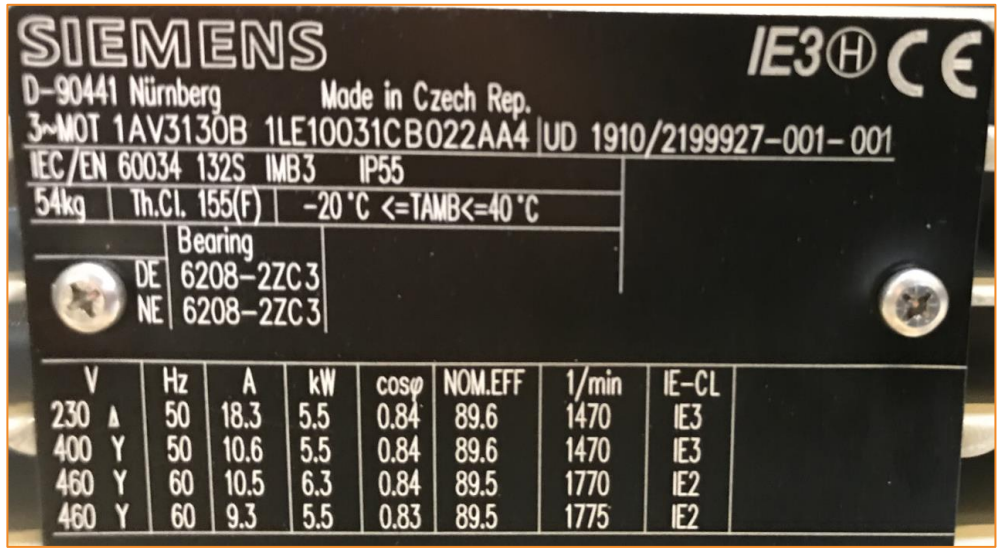
Expected update on water pumps!

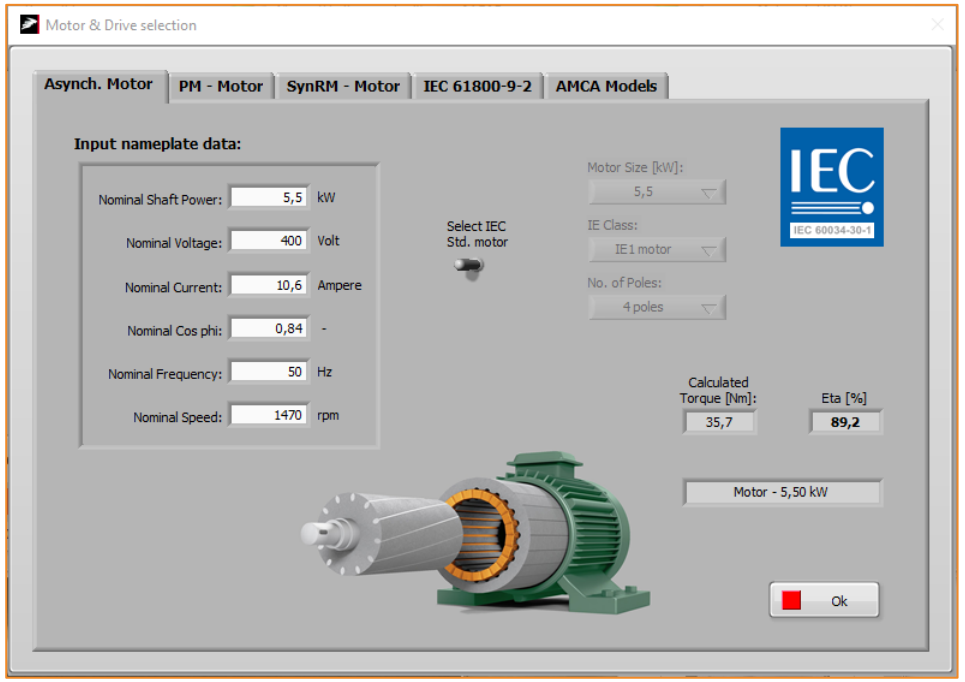
- Ongoing review
- Expected feedback from MSA's Q4
- Adoption & publication by mid 2025

Electric Motor Systems EMSA

The Motor Systems Tool

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



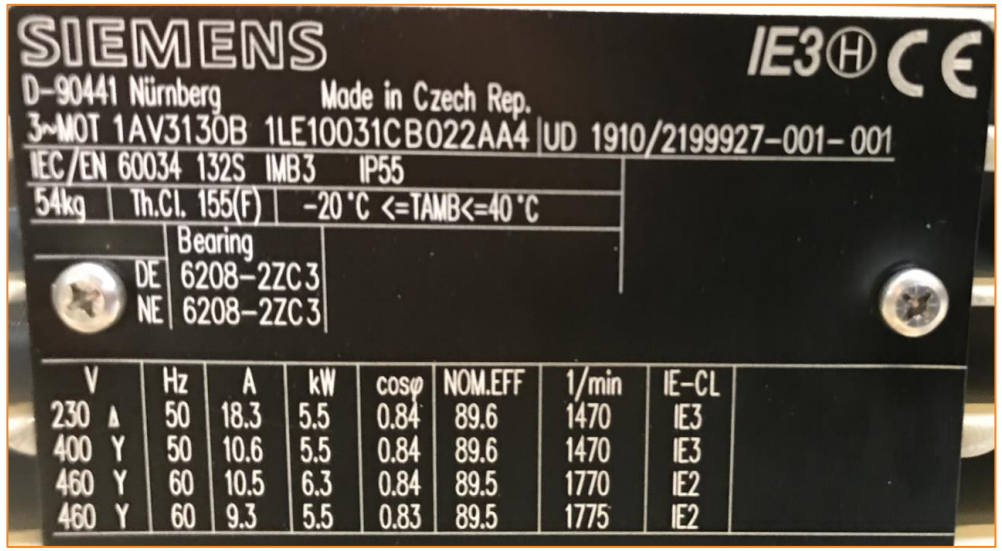


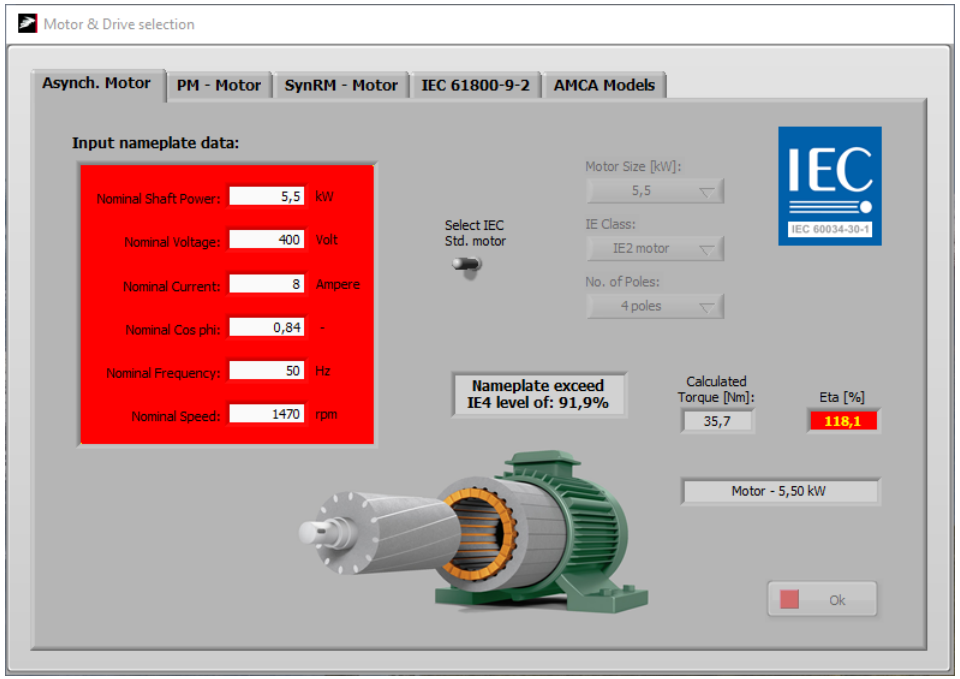
Asynchronous motor – 5.5 kW from nameplate

Electric Motor Systems EMSA

The Motor Systems Tool

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



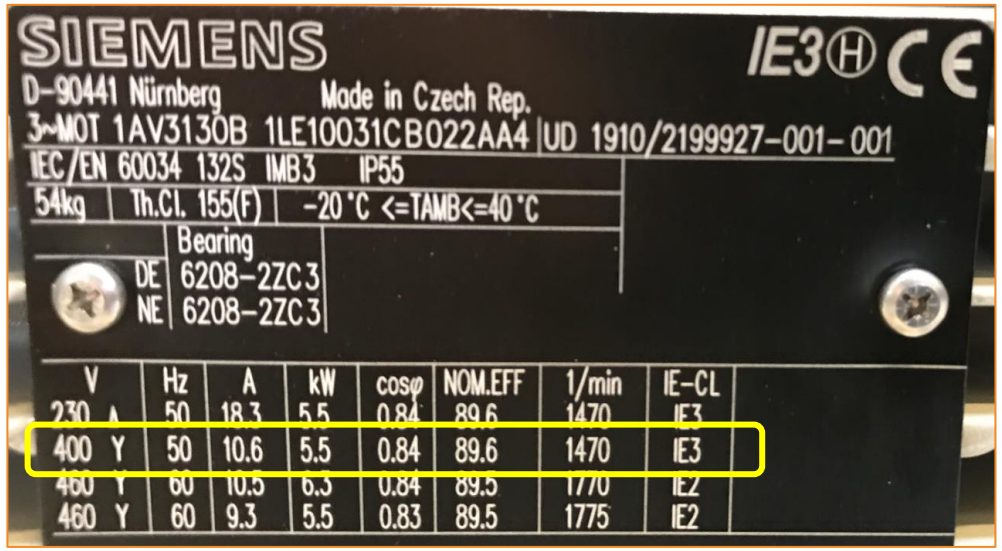


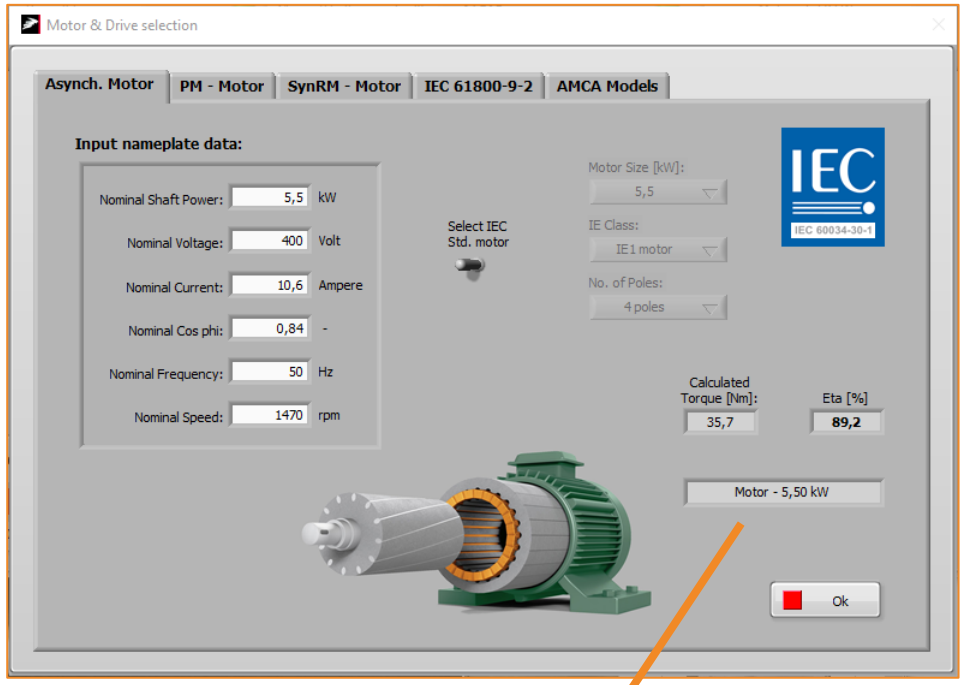
Warning based on calculated efficiency

Electric Motor Systems EMSA

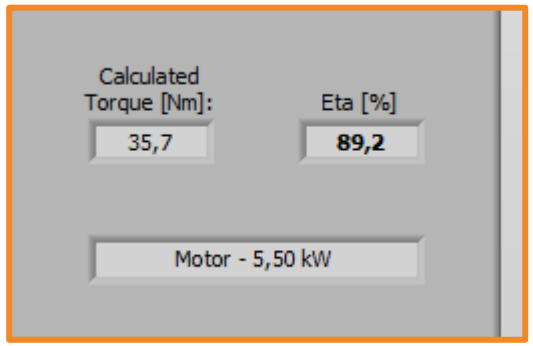
The Motor Systems Tool

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





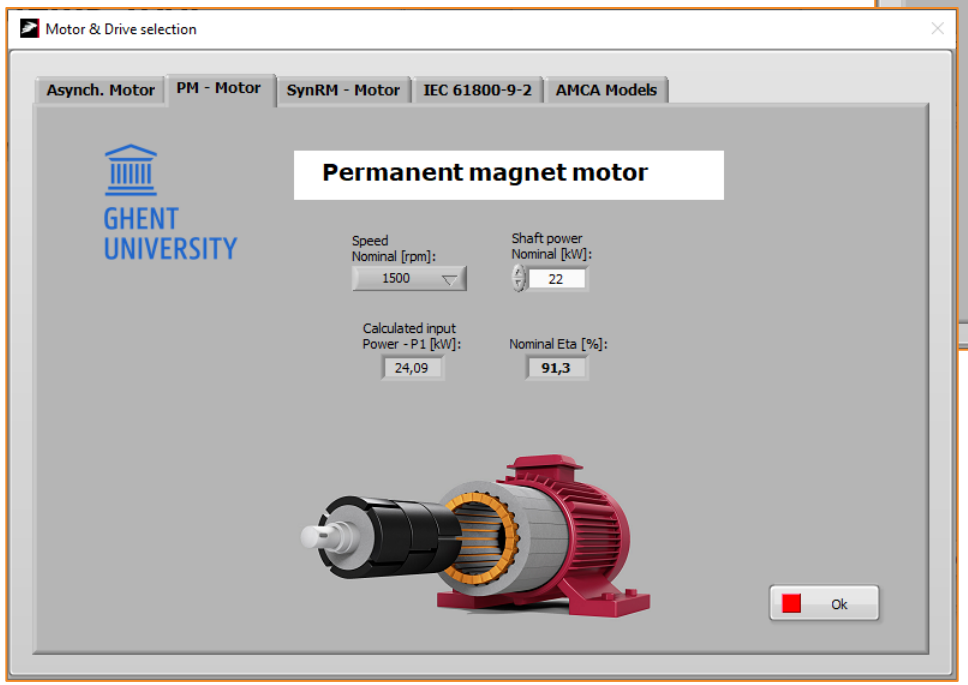
Asynchronous motor – 5.5 kW from nameplate

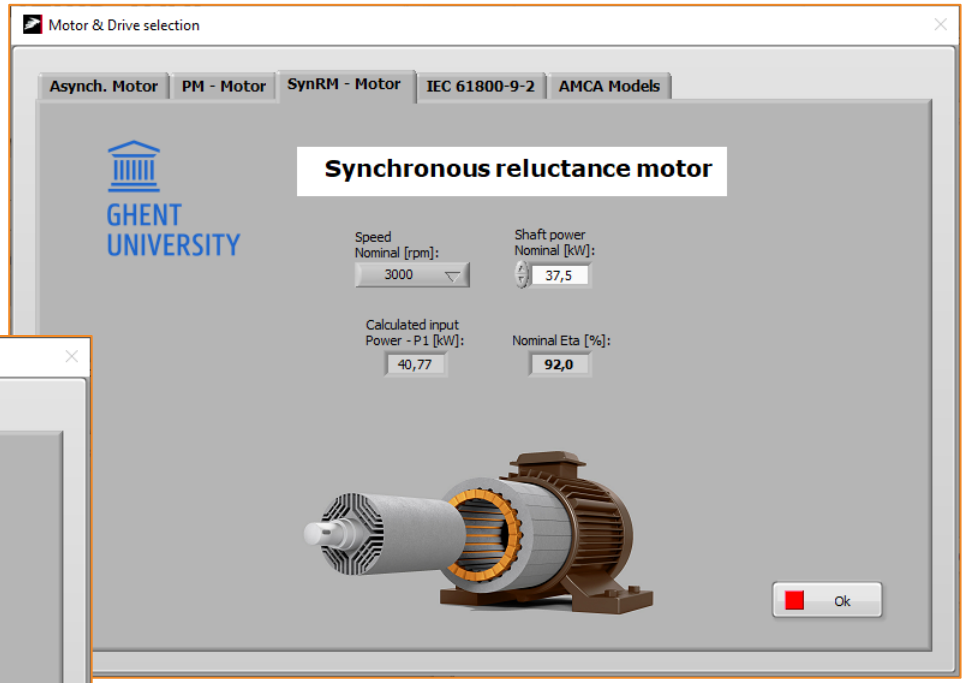


4E Electric Motor Systems EMSA

The Motor Systems Tool

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



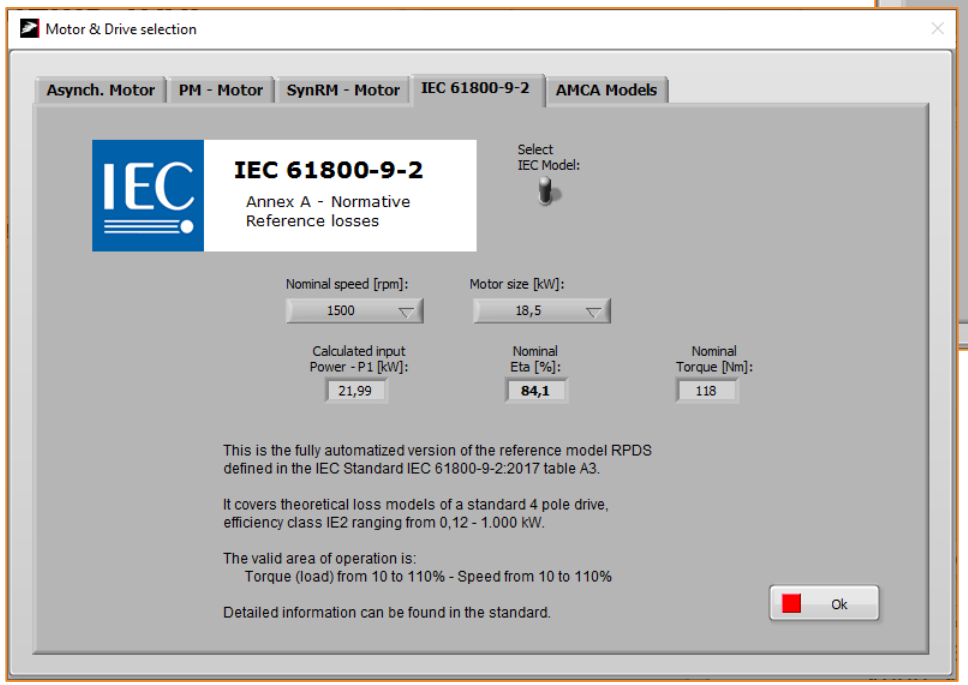


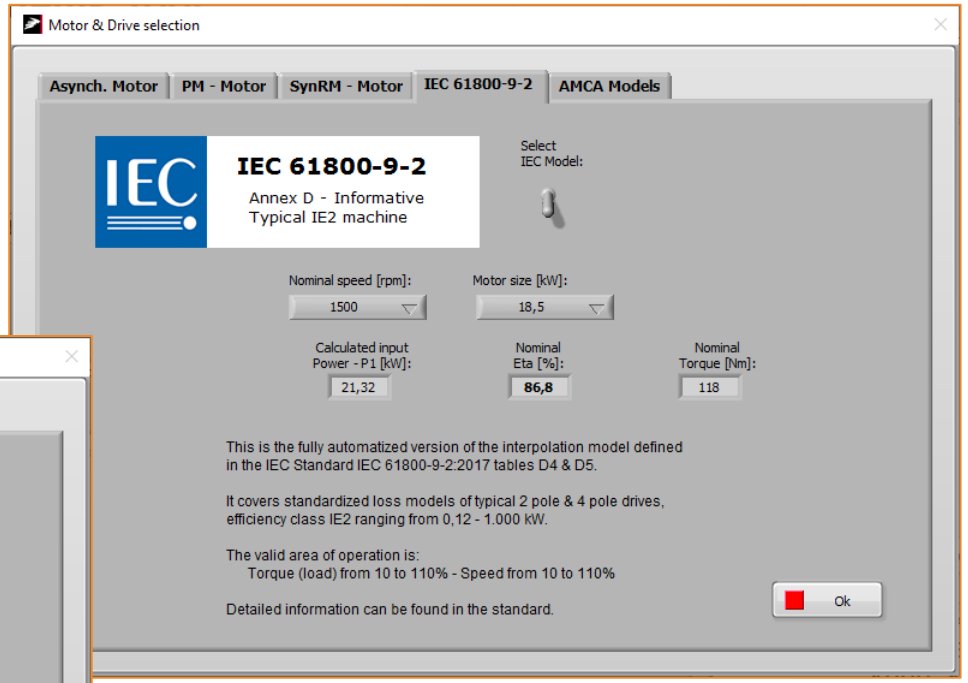
- Models validated in:
  - Shaft power
    - 0.25 – 250 kW
  - Nominal speeds
    - 1.000, 1.500 & 3.000 rpm

Electric Motor Systems EMSA

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

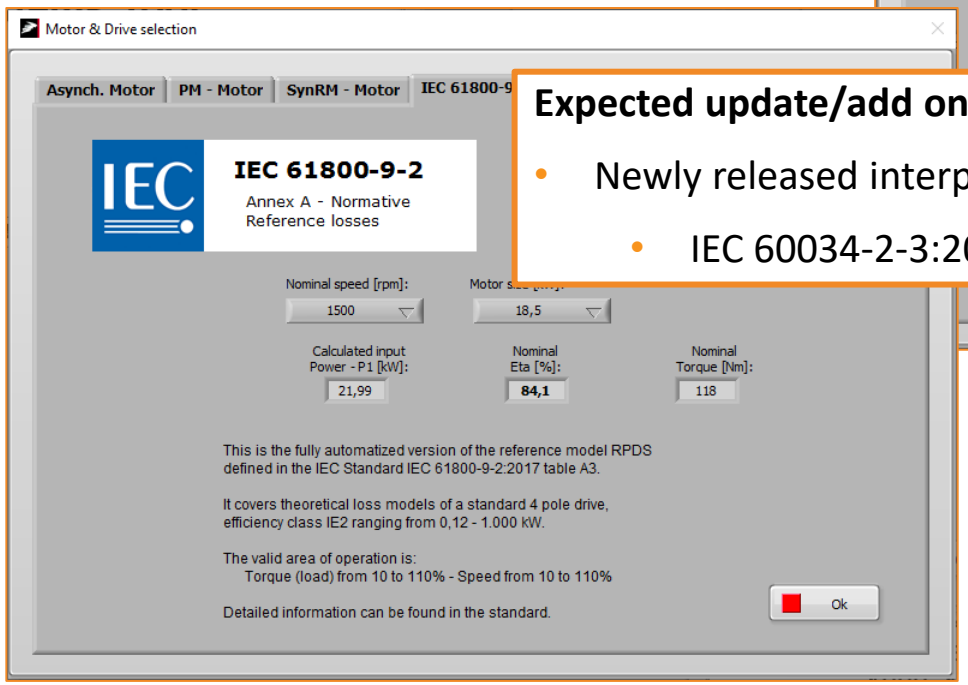


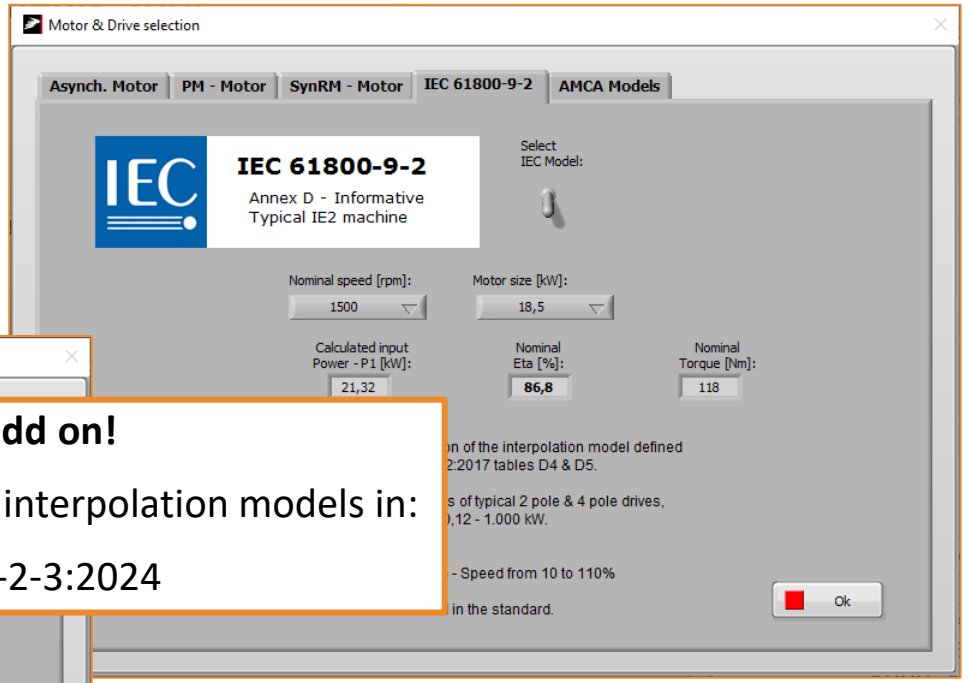


  - Annex D, “Typical” losses when driven by VSD
    - 0.12 – 1.000 kW, 2&4 pole machines, IE2

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!

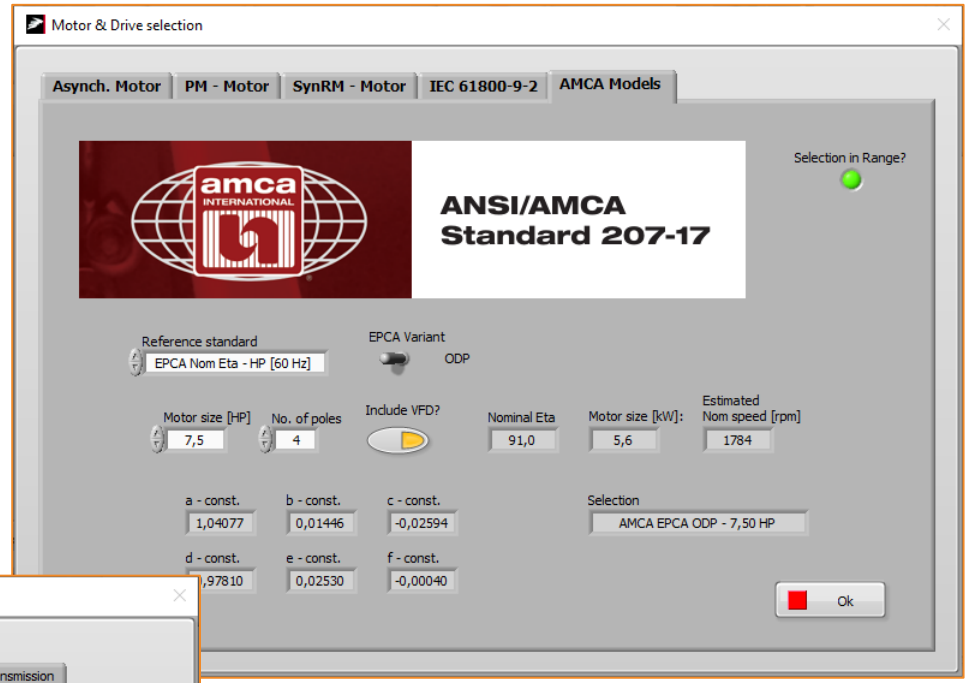
- Newly released interpolation models in:
  - IEC 60034-2-3:2024

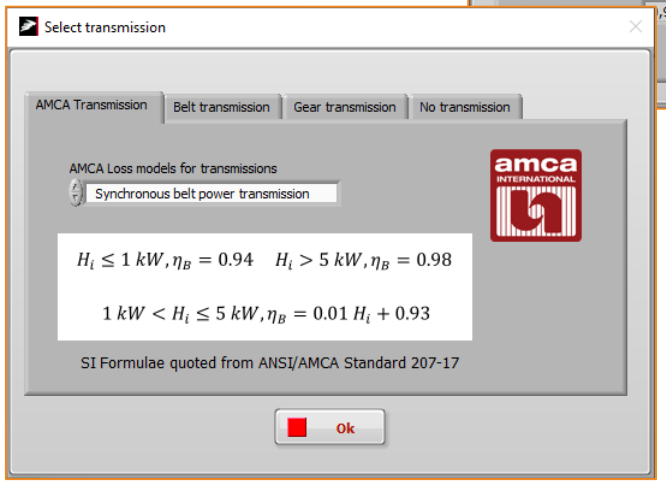
  - Annex D, “Typical” losses when driven by VSD
    - 0.12 – 1.000 kW, 2&4 pole machines, IE2

Electric Motor Systems EMSA

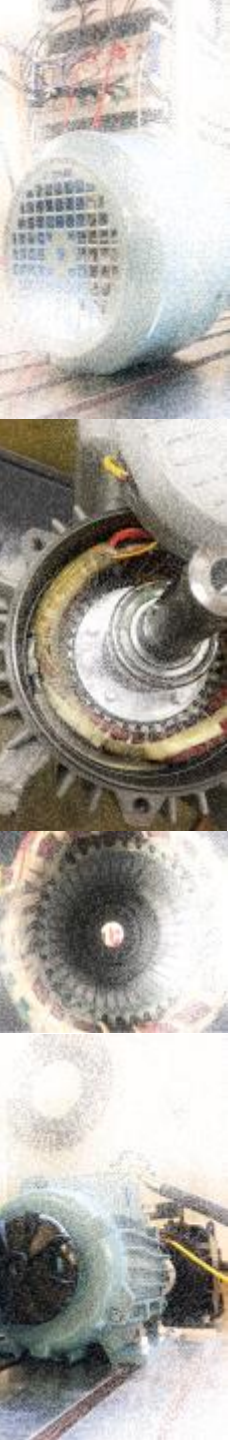
The Motor Systems Tool

- 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





Electric Motor Systems EMSA

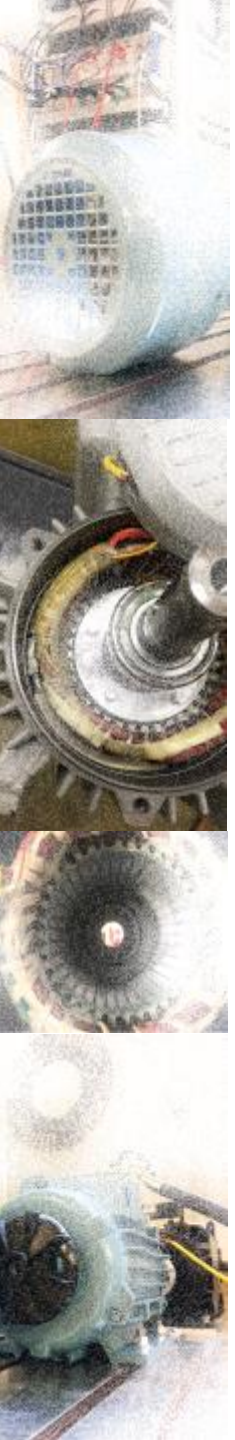


The Motor Systems Tool – Pump example

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



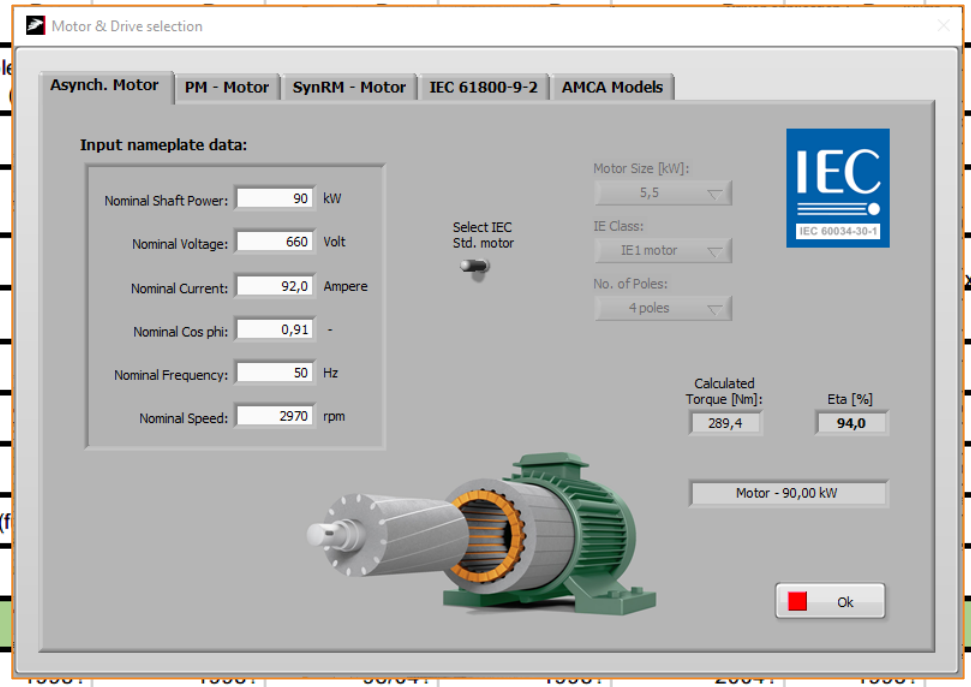
Application Number / Name		P1							
Driven application	(Pump, Fan, Compr., Other)	Pump	Pump	Pump	Pump	Pump	Pump	Pump	Pump
Control method	(throttle/valve; on/off; hydraulic; VSD)	multiple valves (manual+control)	multiple valves (control)	valve	none	multiple valves (control)	multiple valves (control)	valve	none
Annual running hours	(hours/year)	4250	4250	4250	6570	4250	8500	8500	8000
Duration curve *)	(PID; bell curve; 80%)	60-80%	?0% control valve		100%	bell	bell	90%	100%
ATEX	(y/n)	n	n	n	n	n	n	n Ex nA II T3	n Ex nA II T3
Redundant	(y/n)	1oo2	1oo2	1oo2	3oo4	1oo2	n	n	n
Motor Power	(nameplate in kW)	**90**	**45**	**110**	**315**	**37**	**22**	**11**	**160**
Motor nominal speed	(rpm)	2970	2955	2900	1500	2950	2931	1460	1486
Motor current	(A)	92	48	112	328	39,4	22,9	17,1	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)	),84 (full load)	),86 (full load)
		0,91	0,89	0,9	0,87	0,89	0,91	0,84	0,86
Motor efficiency	(%)	95	93,5	94,8	96,7	92,8	92,1	88,3	96
Motor age [years, or year of built]	(years or year of built)	1998?	1998?	1998?	98/04?	1998?	2004?	1993?	2004?
Rewoundings	(y/n)								
Motor Voltage	(400V, 500V, 690V, other)	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

Electric Motor Systems EMSA

The Motor Systems Tool – Pump example



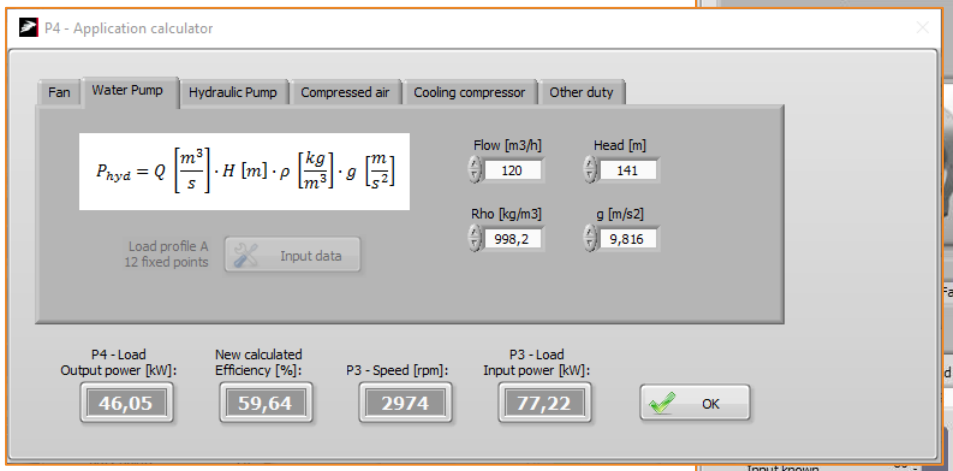

Application Number / Name		P1							
Driven application	(Pump, Fan, Compr., Other)	Pump							Pump
Control method	(throttle/valve; on/off; hydraulic; VSD)	multiple valves (manual+control	multiple						none
Annual running hours	(hours/year)	4250							8000
Duration curve *)	(PID; bell curve; 80%)	60-80%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

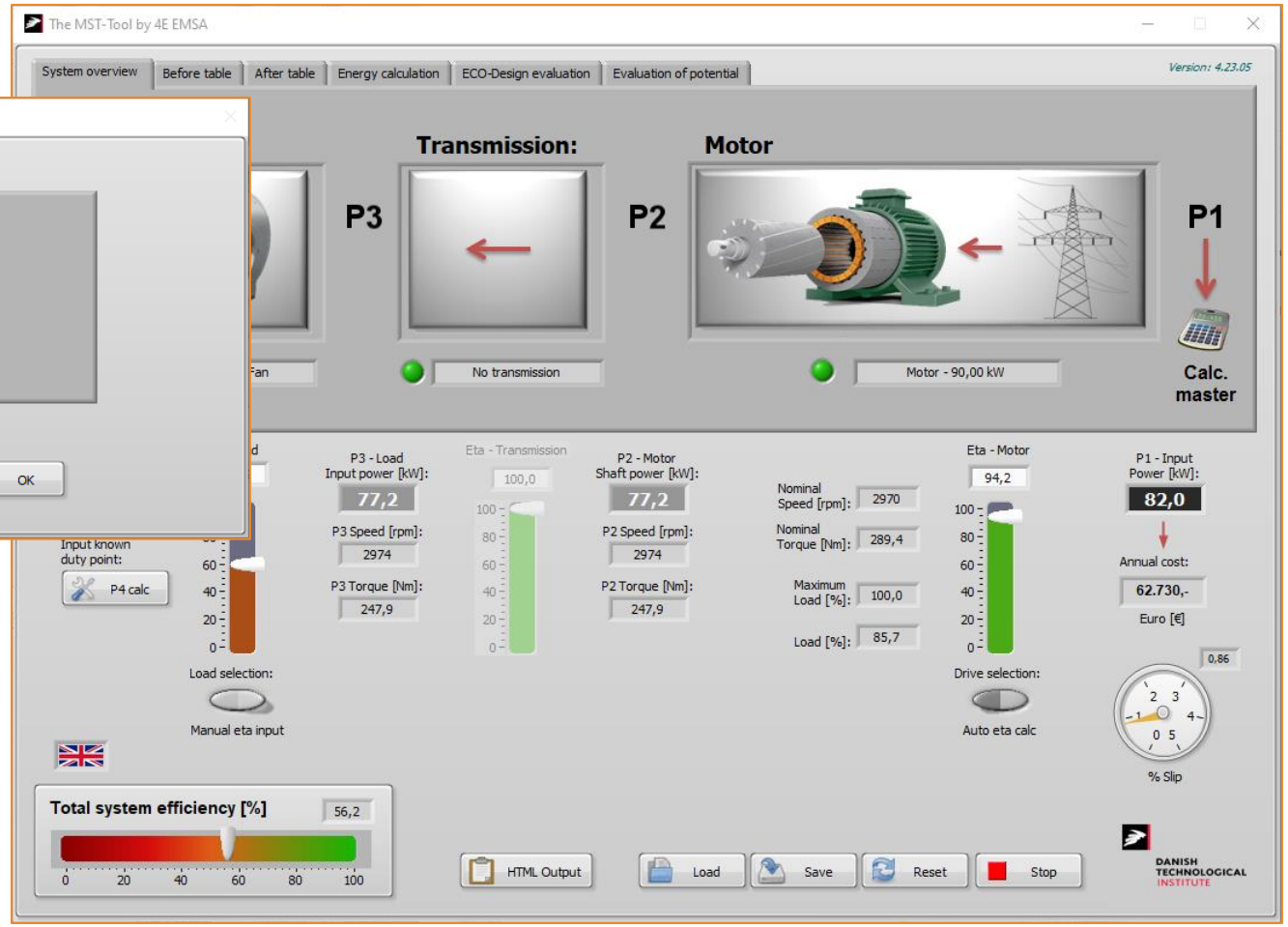


Electric Motor Systems EMSA

The Motor Systems Tool – Pump example

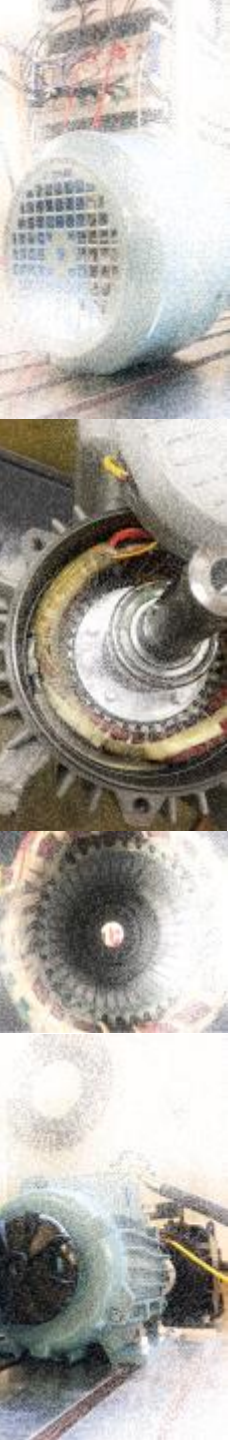
- Inputs in MST-Tool:





- 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.

Electric Motor Systems EMSA



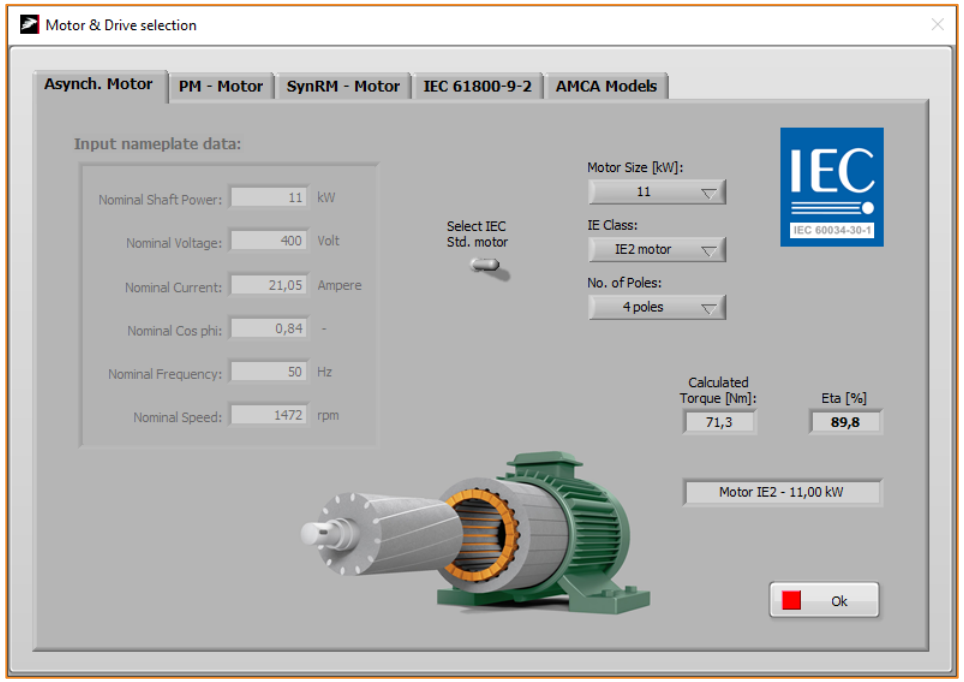
The Motor Systems Tool – 12 duty points

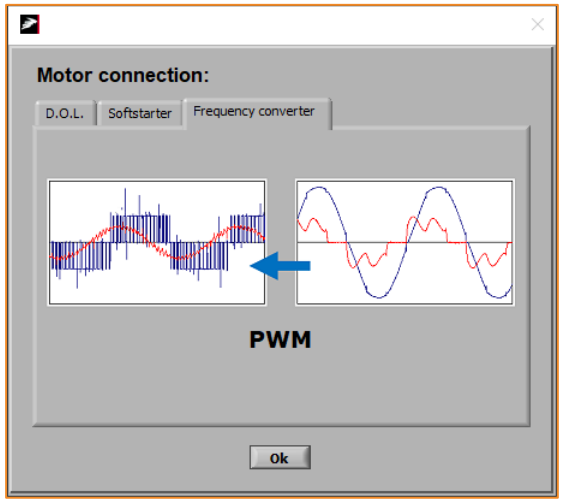
Another example, 12 points in application calculator

- 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:

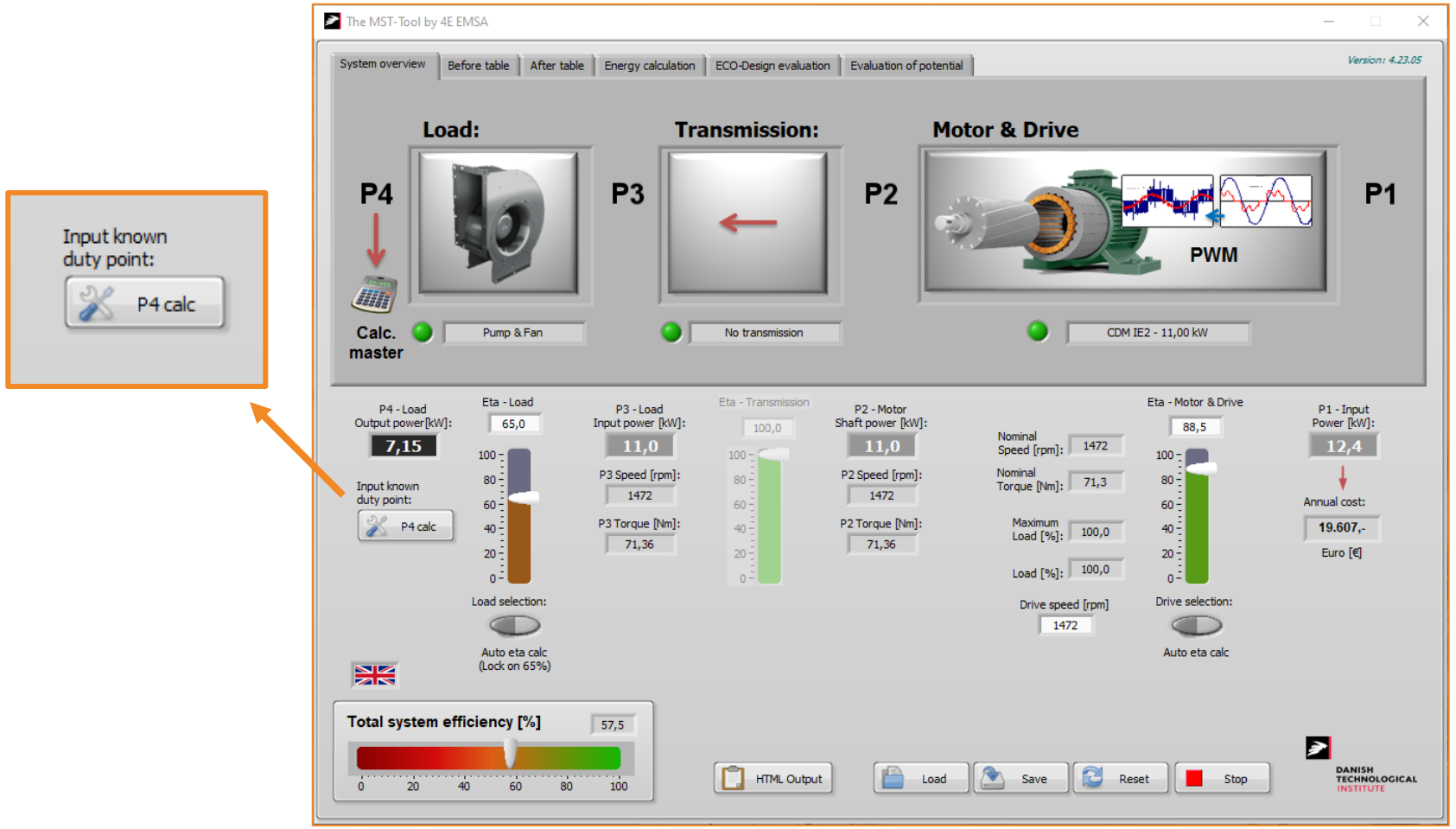




Electric Motor Systems EMSA

The Motor Systems Tool – 12 duty points

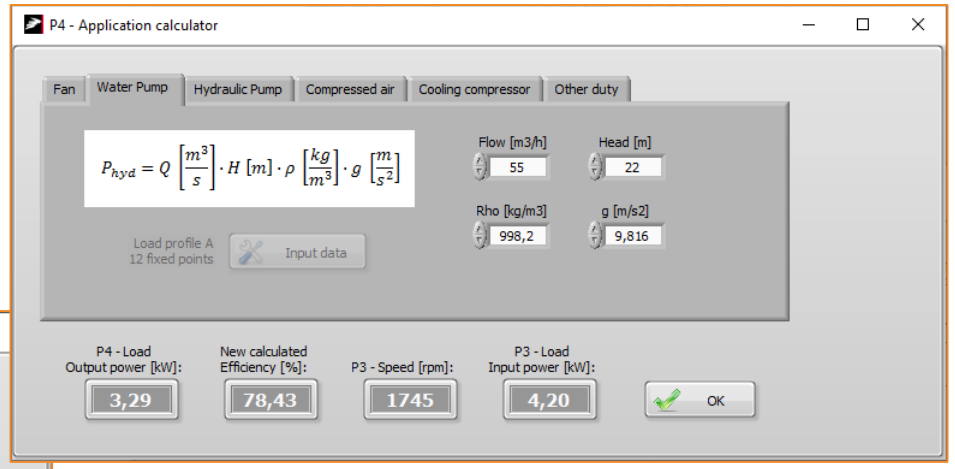
- Application calculator:



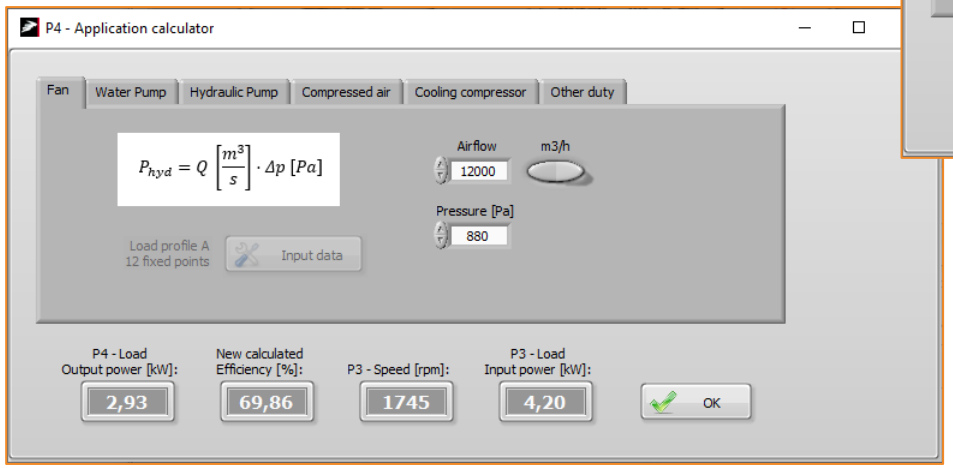
Electric Motor Systems EMSA

The Motor Systems Tool – 12 duty points

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



Pump input page



Fan input page

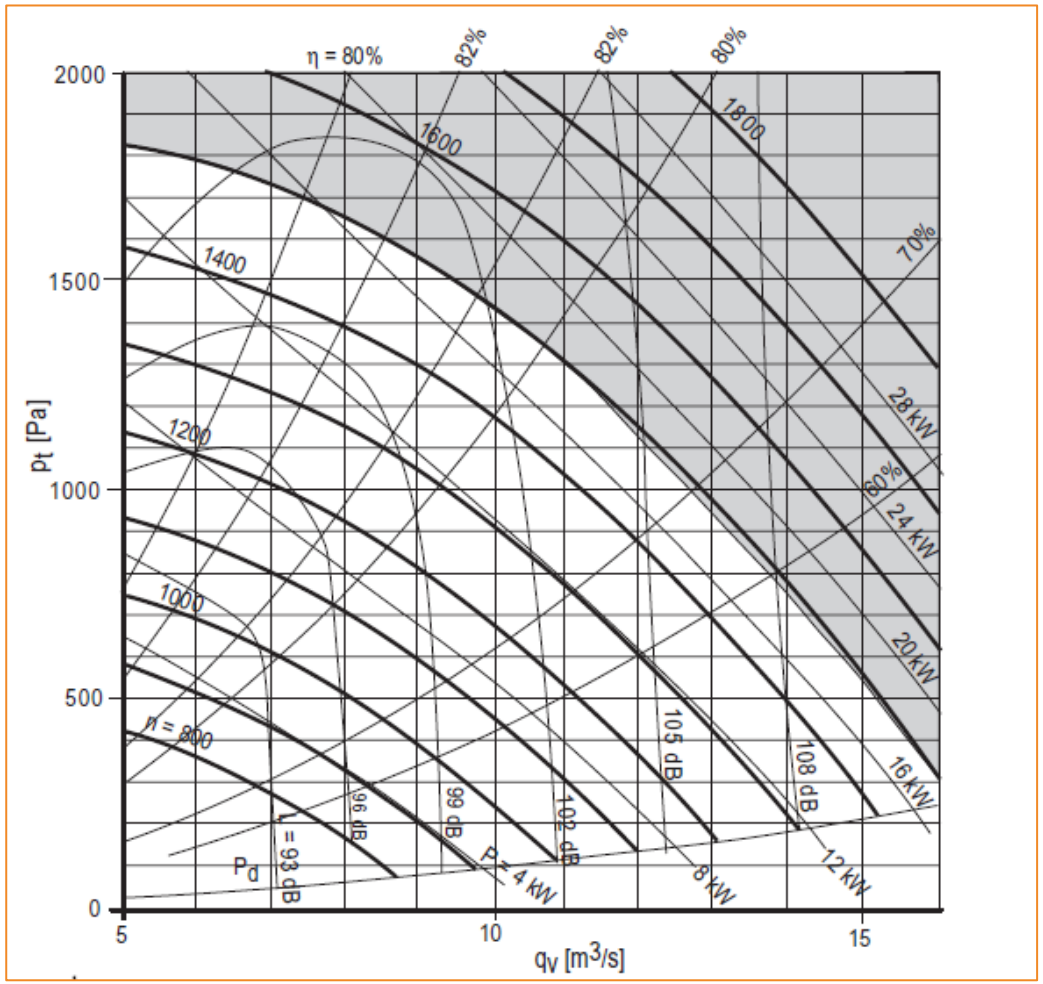
Electric Motor Systems EMSA

The Motor Systems Tool – 12 duty points

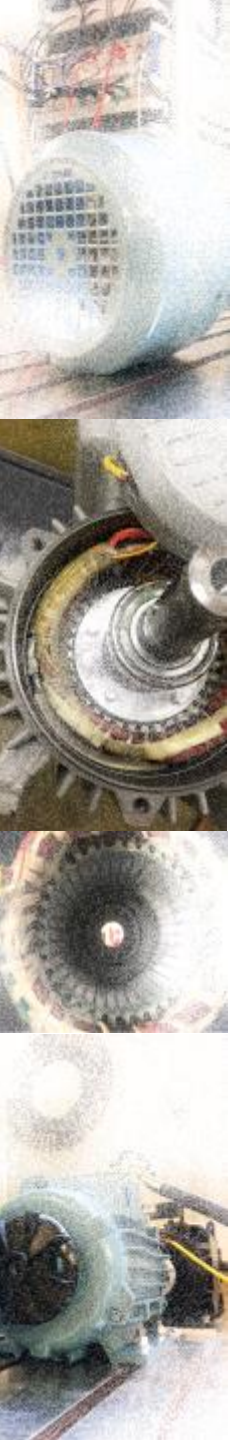
- Application calculator:
  - Includes standardized models for:
    - Pump, Fan, Hydraulic pump
      Air,- & Cooling compressors

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:



Electric Motor Systems EMSA

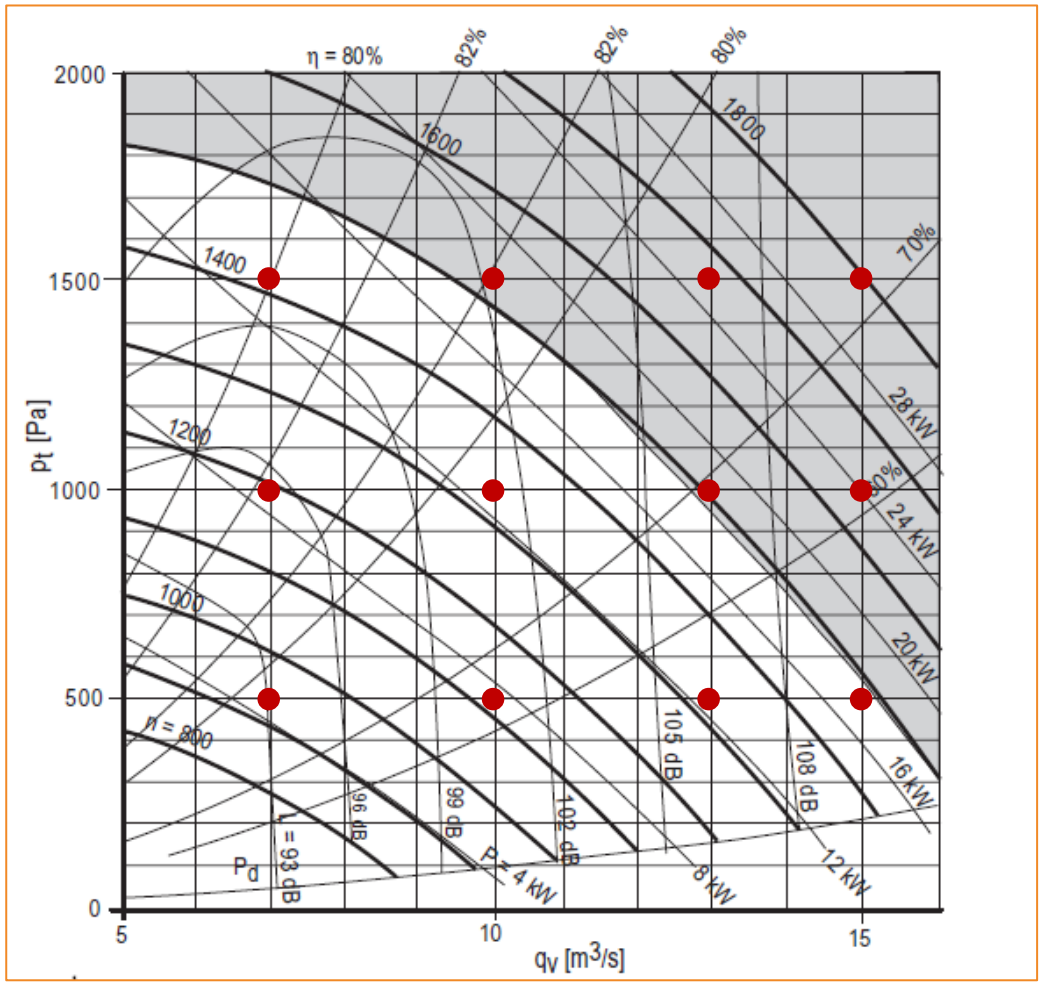


The Motor Systems Tool – 12 duty points

- 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.

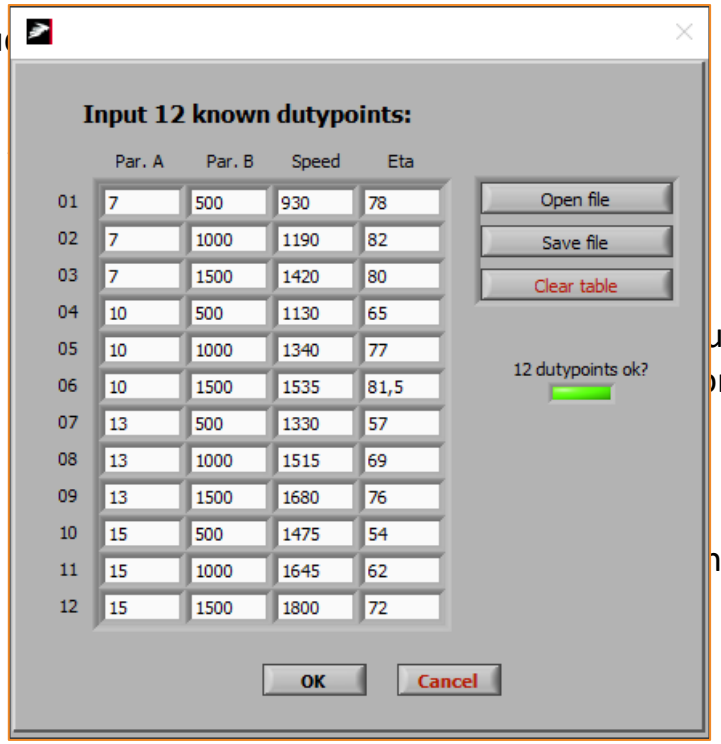
Definition of 12 representative duty points:

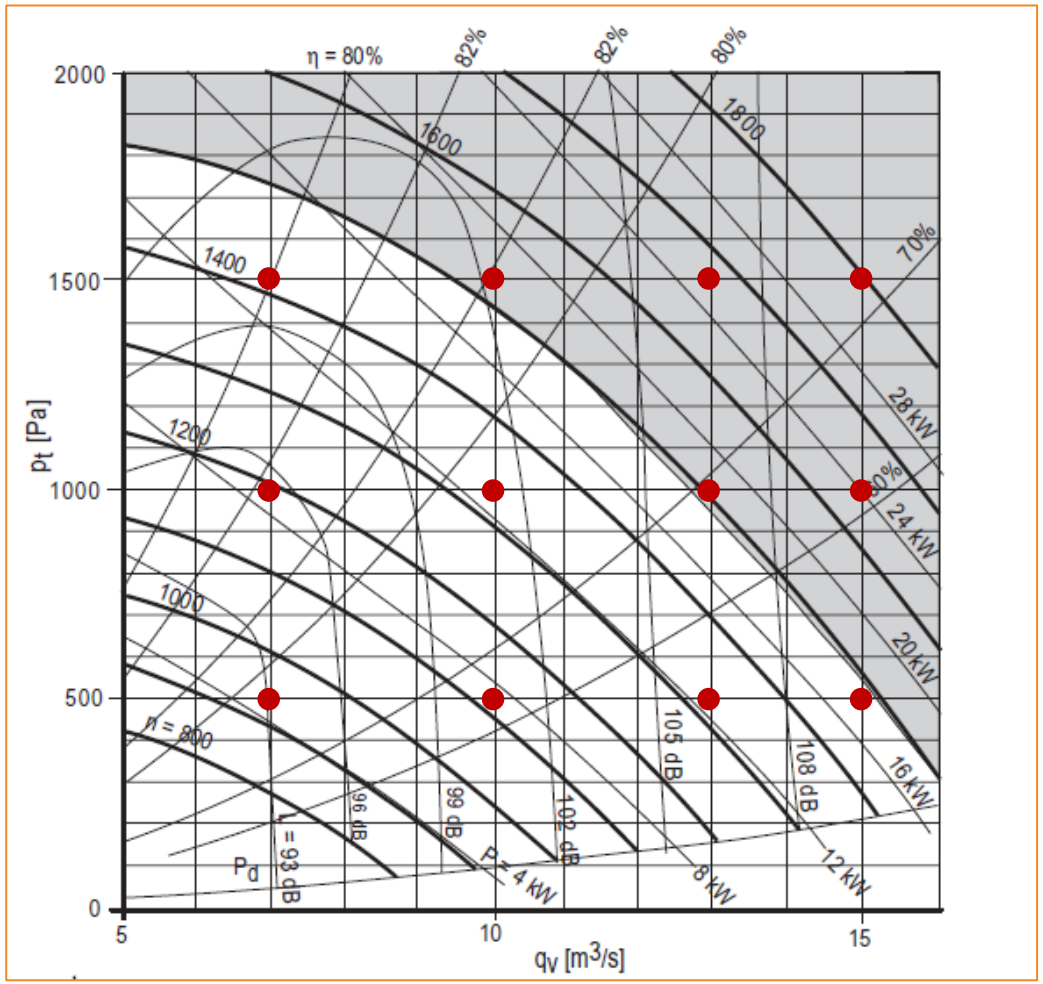


Electric Motor Systems EMSA

The Motor Systems Tool – 12 duty points

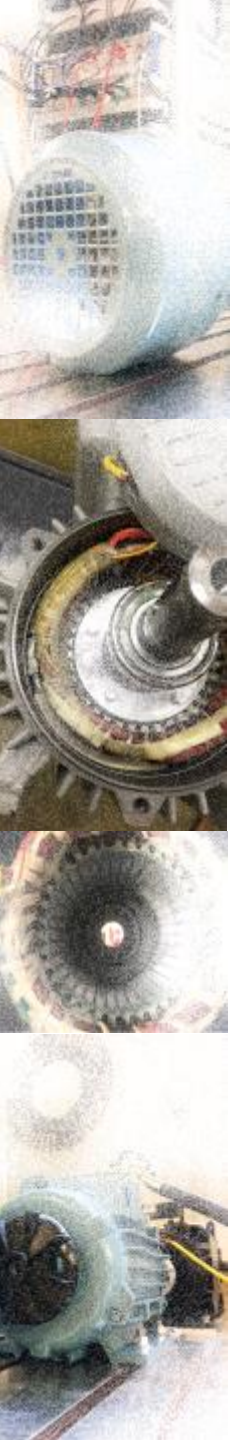
- Application calculator:
  - Inclu
    - ut
    - on
    - nts:





Electric Motor Systems EMSA

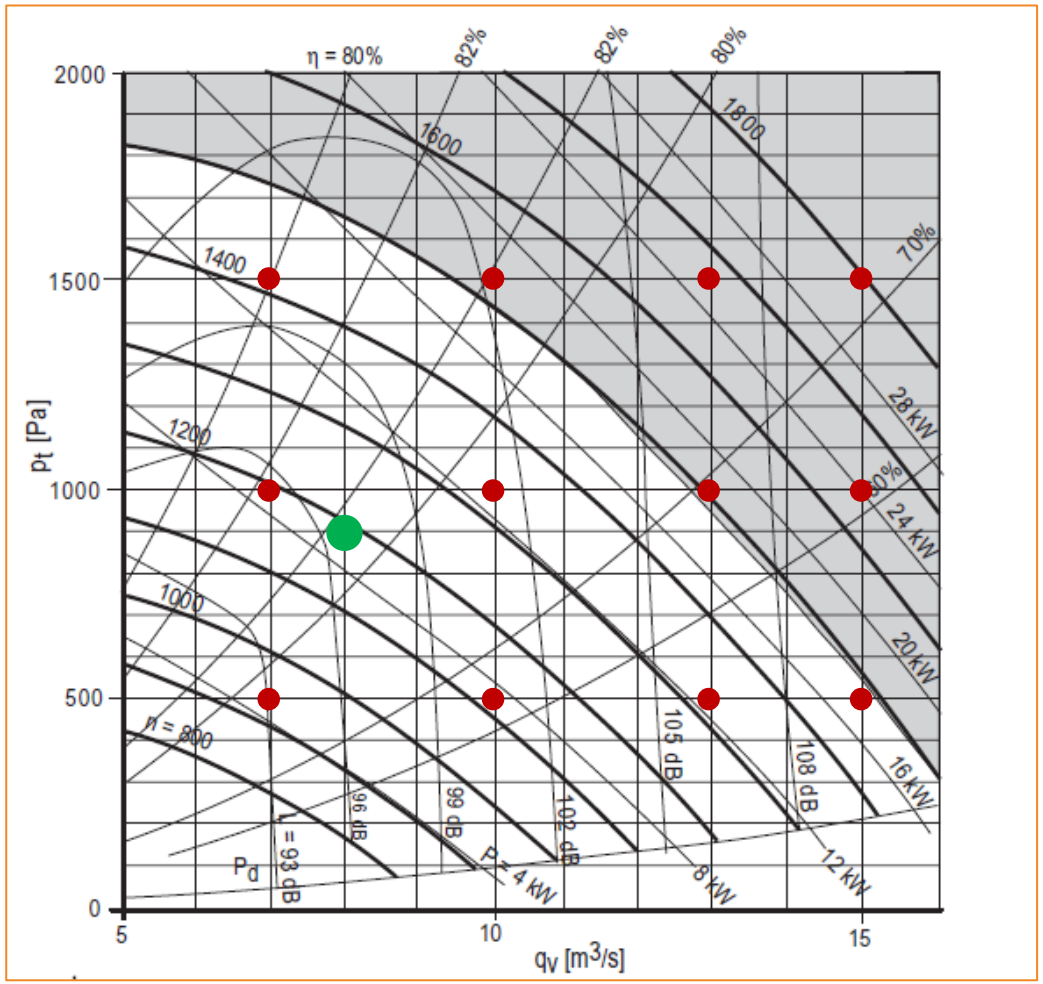
The Motor Systems Tool – 12 duty points



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

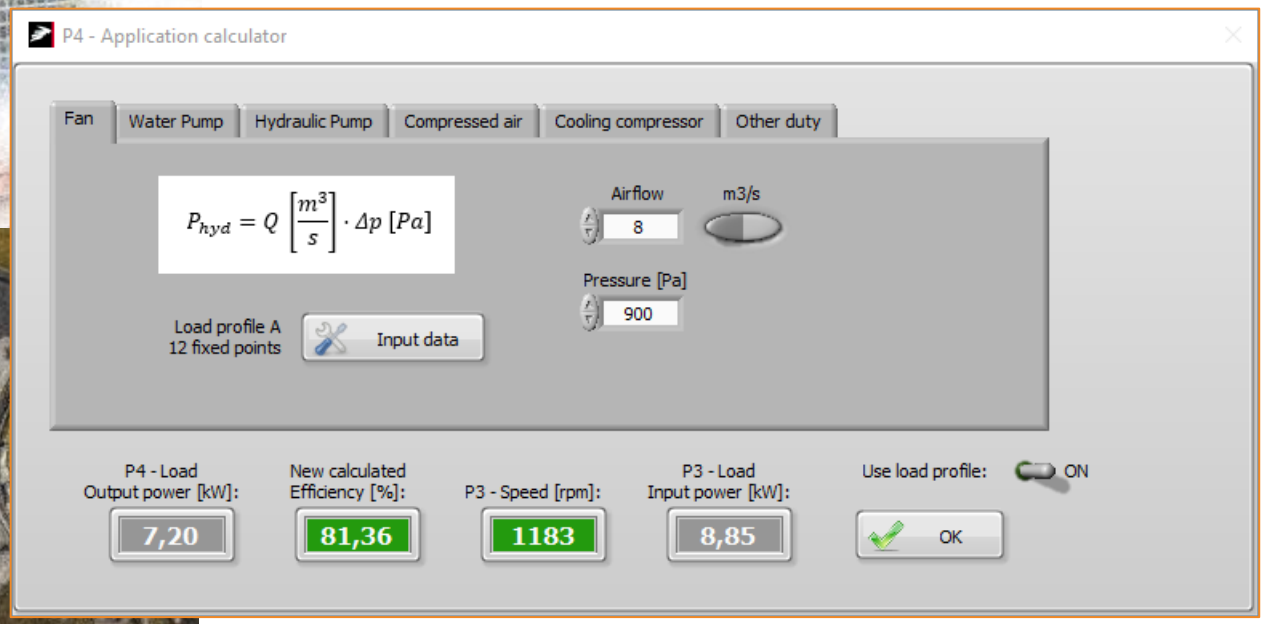
For the “opposite direction” of calculation, both pump & fan have the possibility to input the pump/fan curve for automatic calculation of duty point.

Specific duty point (8 m3/s, 900 pa):

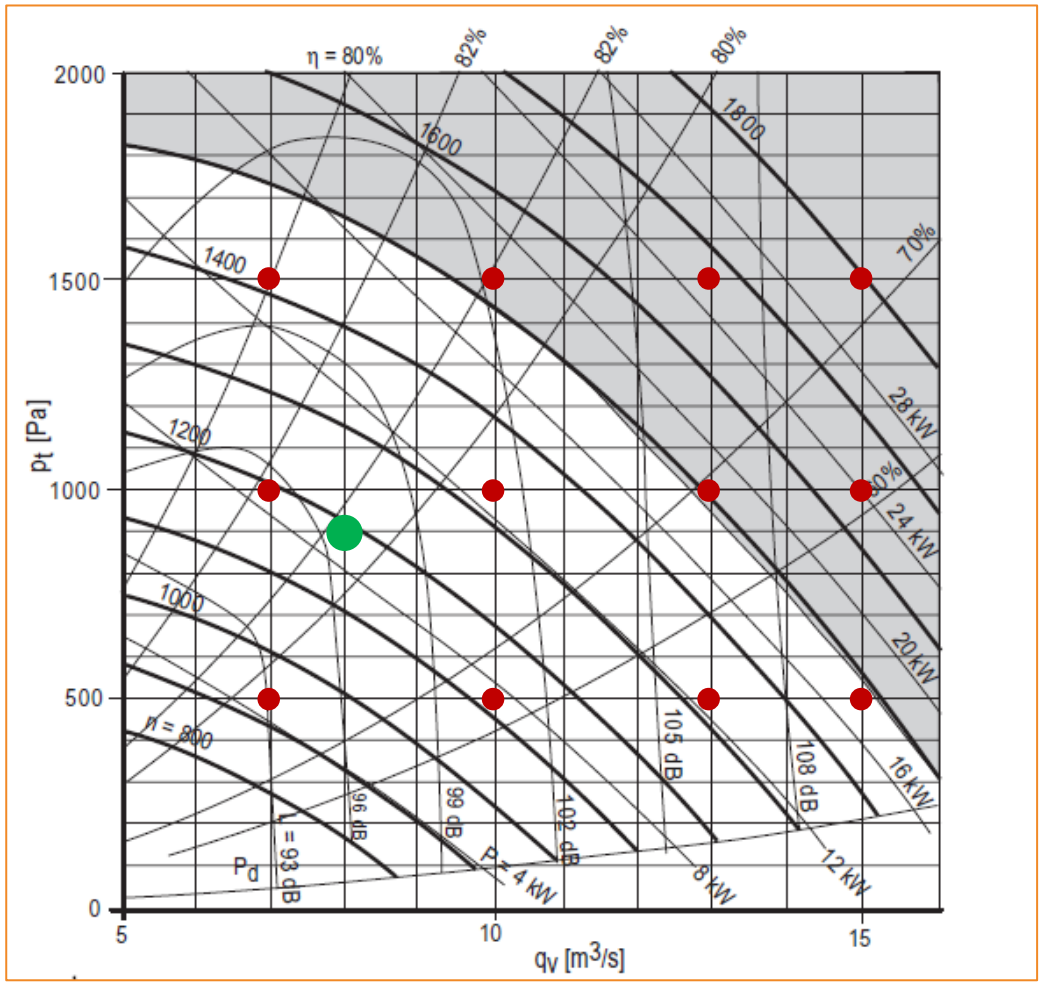


Electric Motor Systems EMSA

The Motor Systems Tool – 12 duty points



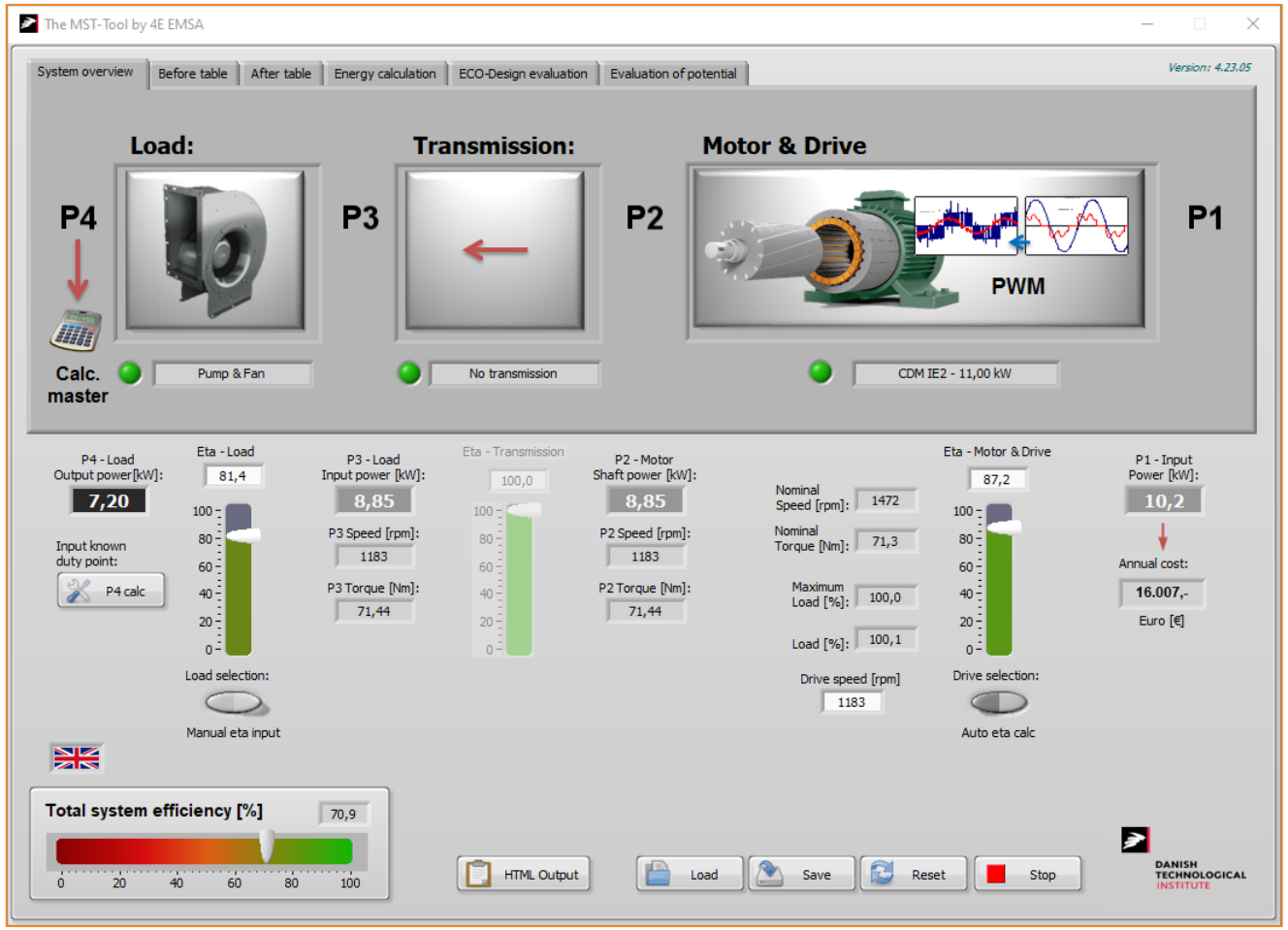
Specific duty point (8 m3/s, 900 pa):



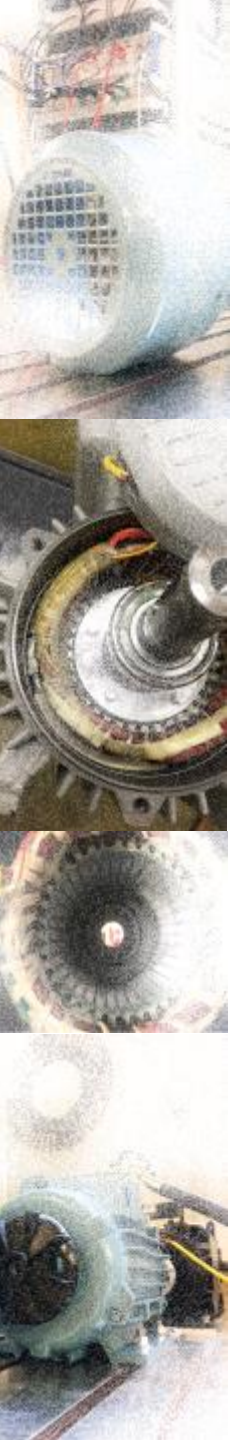
Electric Motor Systems EMSA

The Motor Systems Tool – 12 duty points

- Application calculator:
  - Complete system calculated:



Electric Motor Systems EMSA

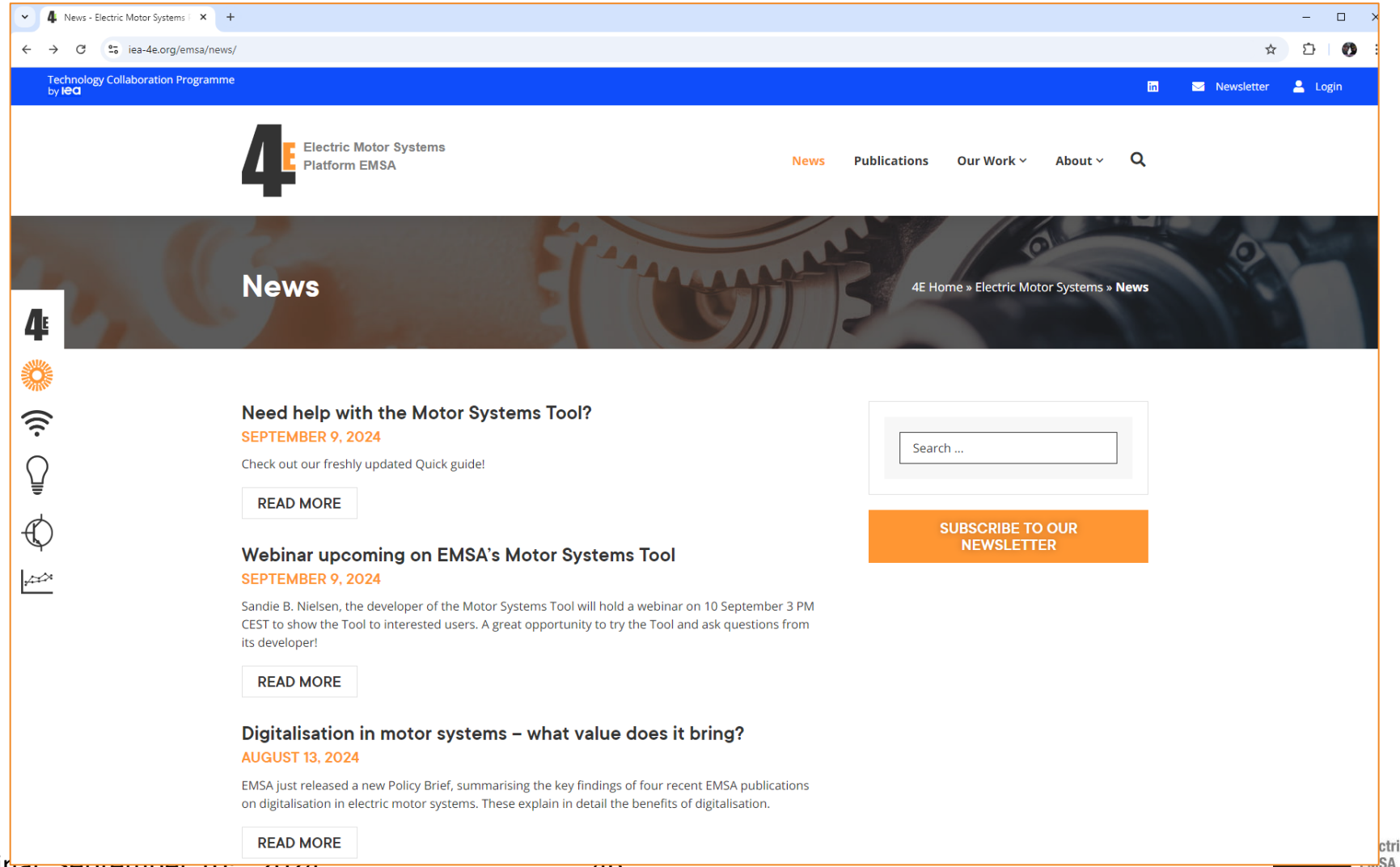


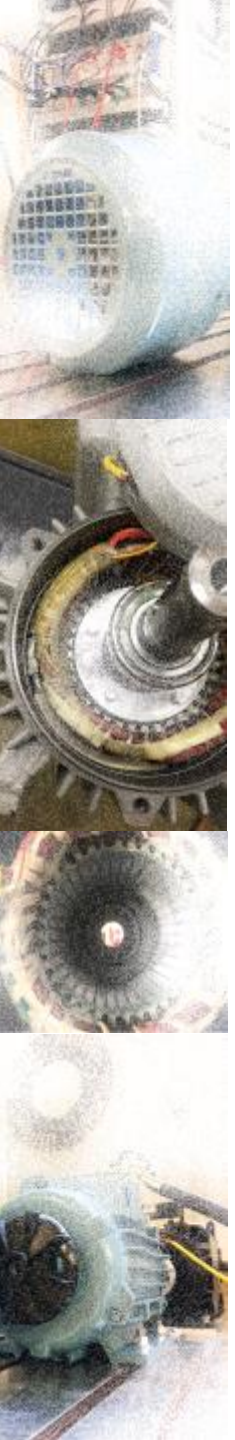
The Motor Systems Tool

- 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





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

4E Electric Motor Systems EMSA