MSTool as energetic optimization guide

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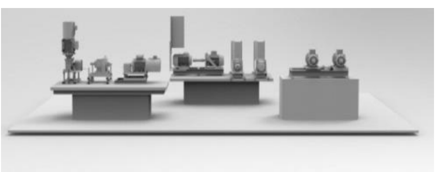
IWT Tetra project nr. 130201



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Studienamiddag 17.12.15

Efficiëntieverhoging Elektromechanische Aandrijvingen

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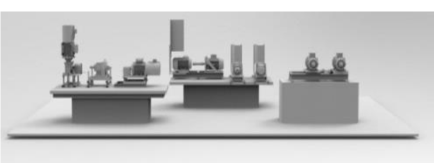
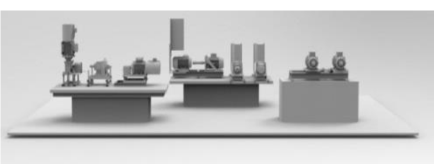
Background MSTool

- Lot of research output on (part load) efficiency of drive train components
- Question : how to give users access to this data?
- Answer : development software tool
  - No such software on the market yet
- Prerequisites :
  - Brand independent
  - “Low level” interface
  - Supported in future



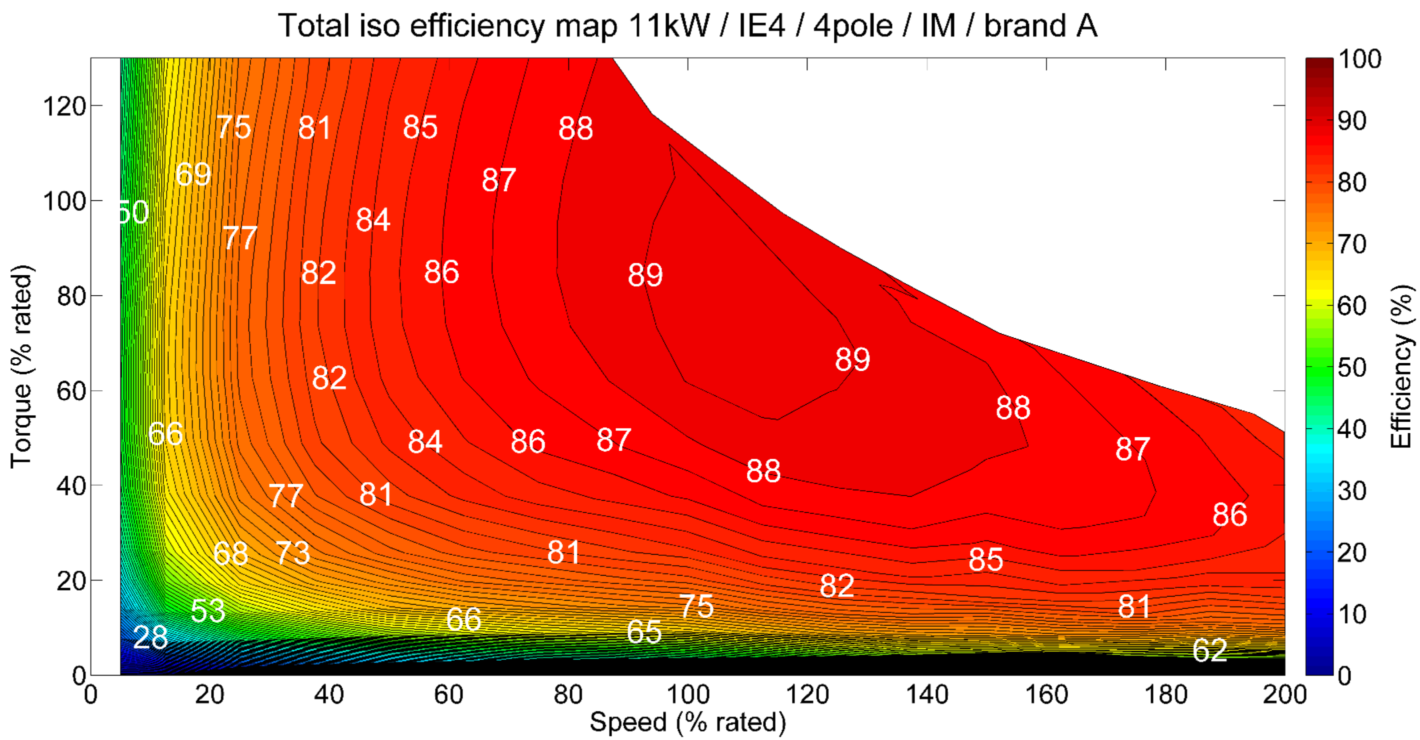
Background MSTool

- MSTool
  - Created by Danish Technological Institute
    - Accreditated testing lab
    - 2011 : First release MSTool @ Washington DC during EEMODS 2011
      - Based on own testing results, brand independent
      - Tool for estimating effects of implementing high(er) efficient drive train components
      - Supported by 4E EMSA (Australia, Denmark, Austria, Netherlands, Switzerland, USA)
    - Target group : engineers, machine builders, energy advisers, ...



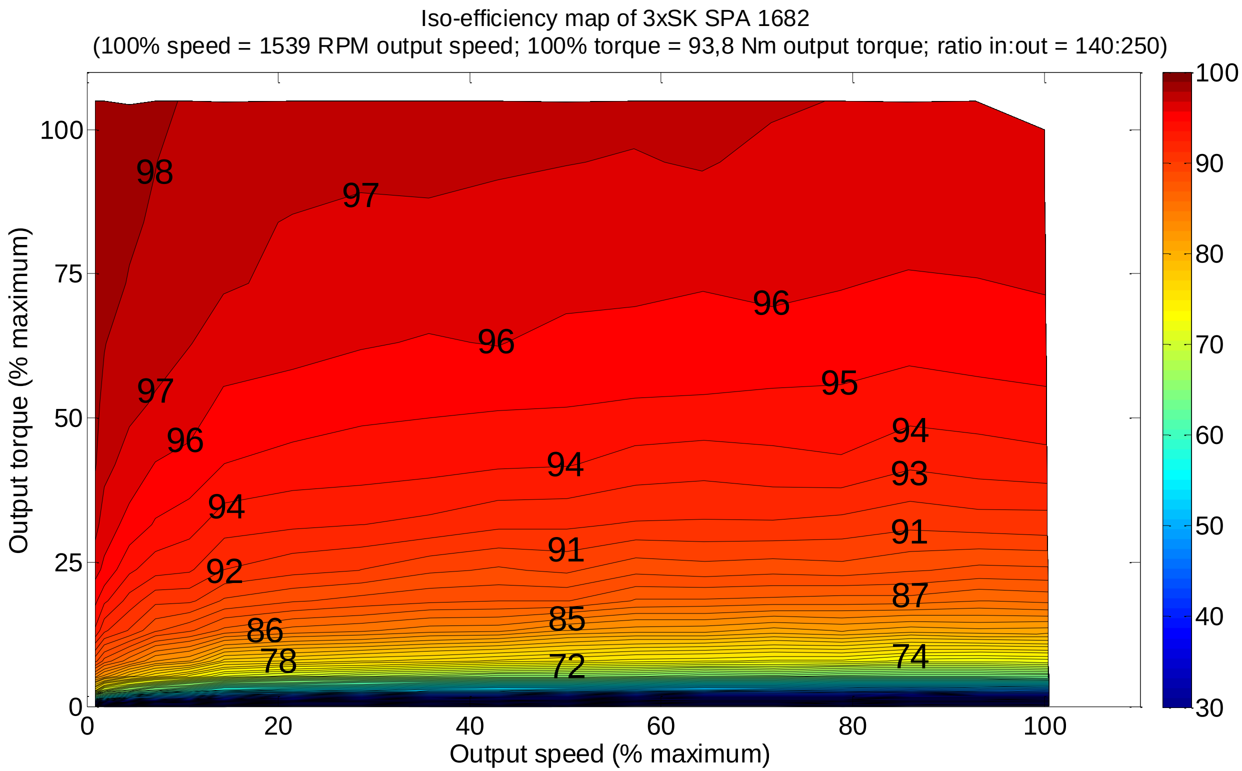
Input MSTool

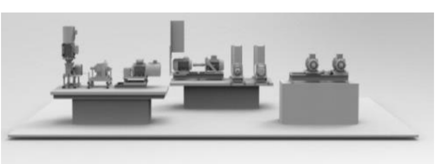
- Efficiency: motor (and drive)



Input MSTool

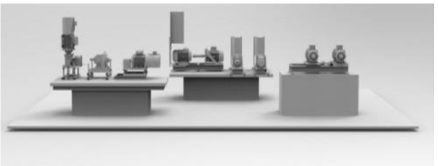
- Efficiency: transmission



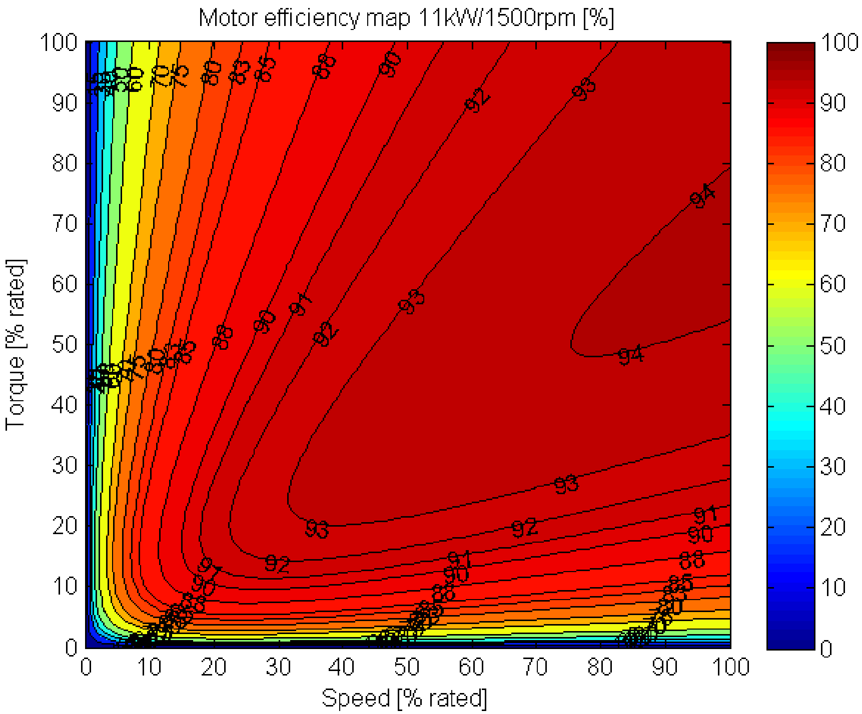


Background MSTool

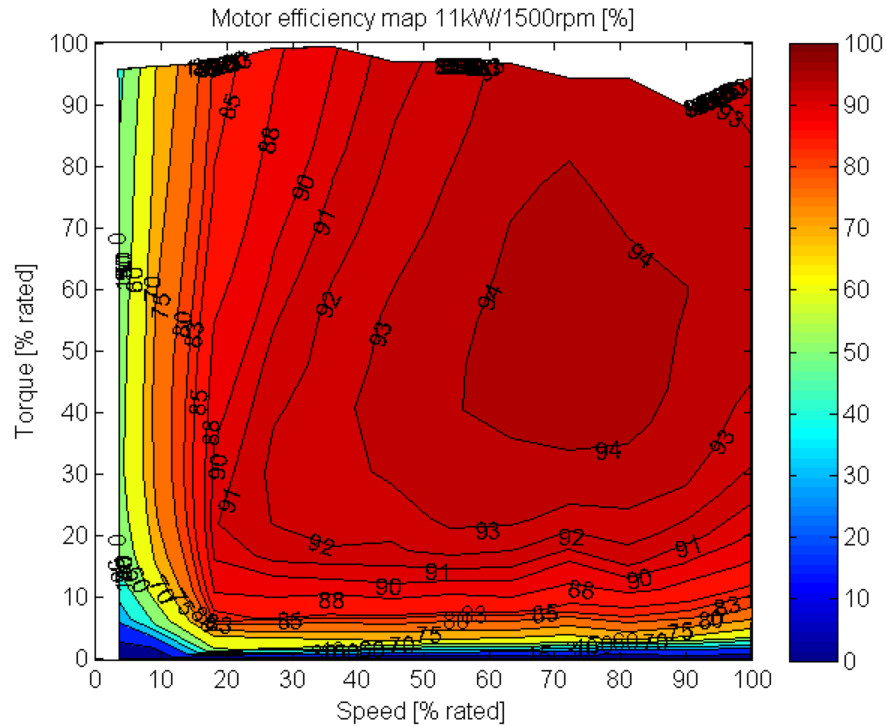
- MSTool UGent
  - Finetuning and adding new data based on own test bench results:
    - Information on efficiency gear boxes
    - Added information on efficiency of permanent magnet motors and sychronous reluctance motors
  - Models and curvefitting performed by colleagues Hendrik Vansompel and Peter Sergeant (EESA)
    - Based on test bench results, own knowledge and constructor information



Some results : PMSM: efficiency maps



Calculated

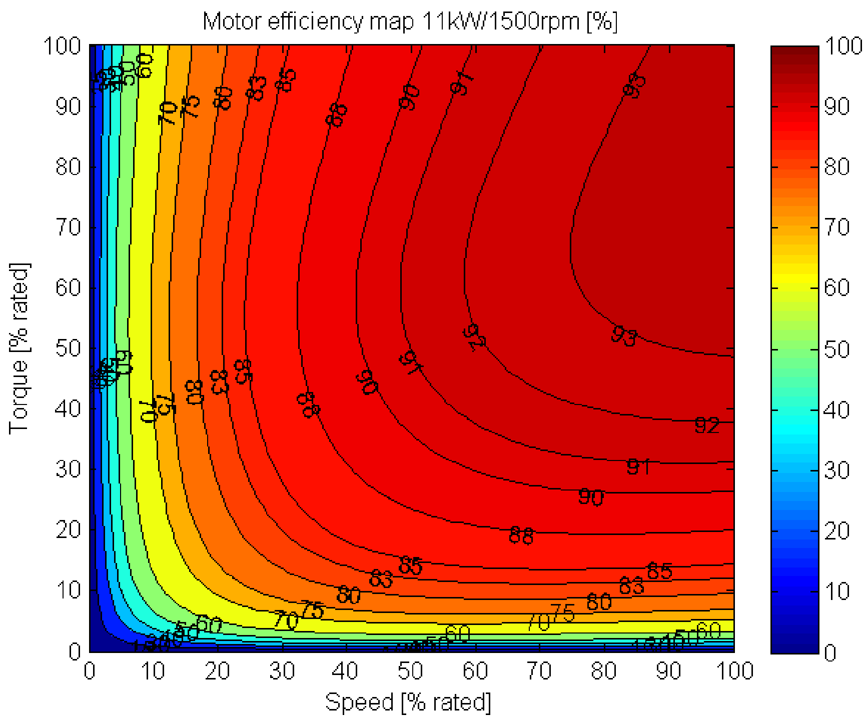


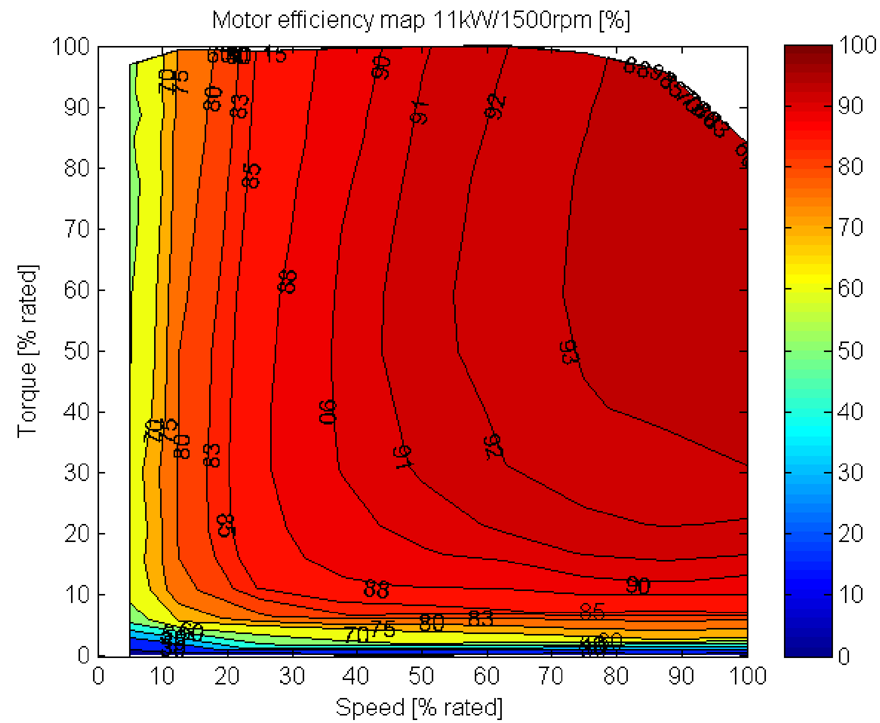
Measured

- Rated efficiency value
- Power loss equations based on test bench results

} Efficiency map **MST**

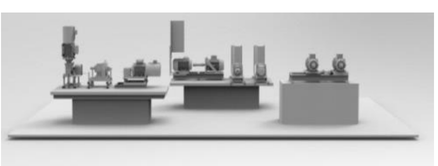
Some results : synRM : efficiency maps



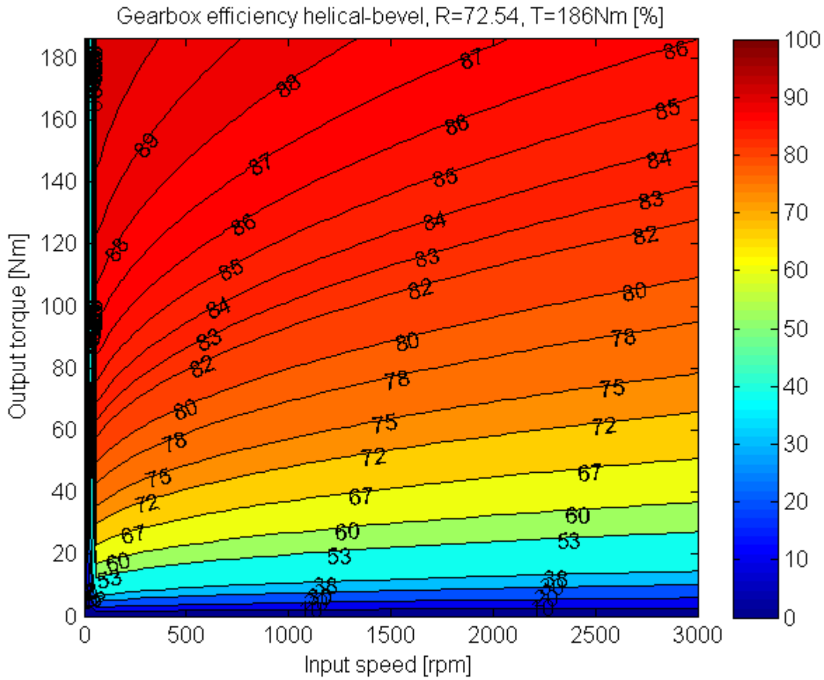


- Rated efficiency value
- Power loss equations

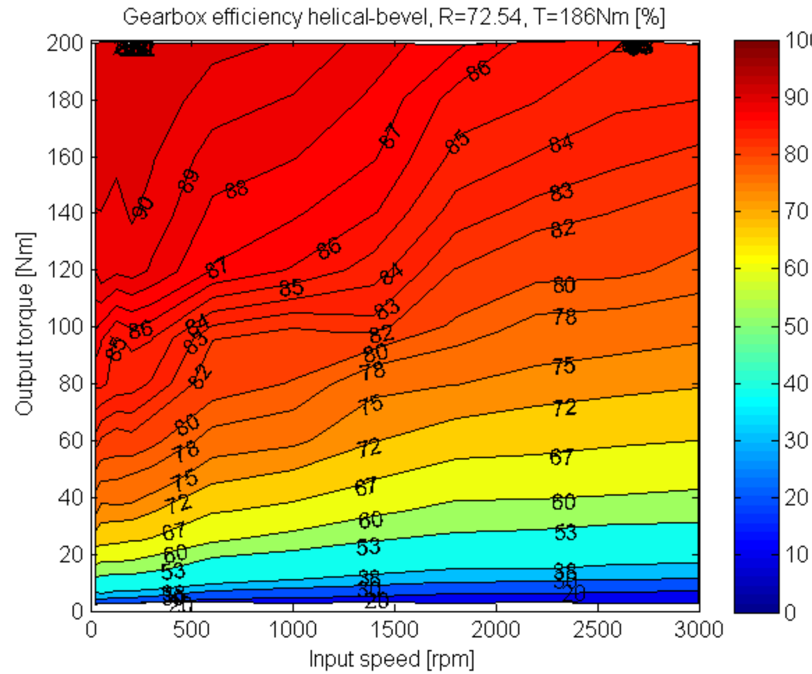
\+ constant flux control } Efficiency map **MST**



Some results : helical-bevel gears : eff maps



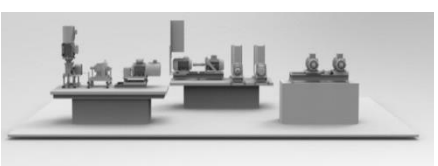
Calculated



Measured

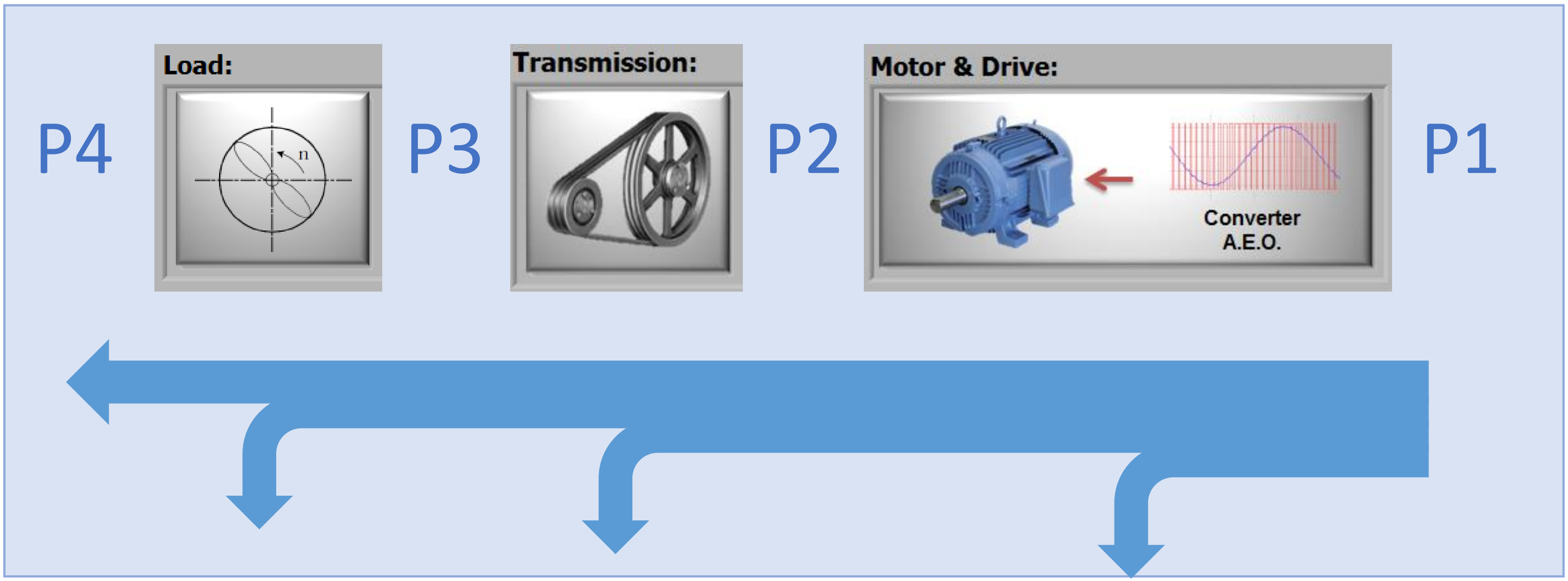
- Rated efficiency value
- Power loss equation with fitted coefficients as a function of gear ratio and output torque

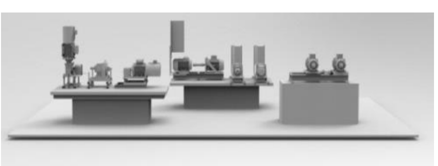
} Efficiency map **MST**



Basic setup MSTool

- Target: estimating complete drive train energy efficiency for a new or existing installation

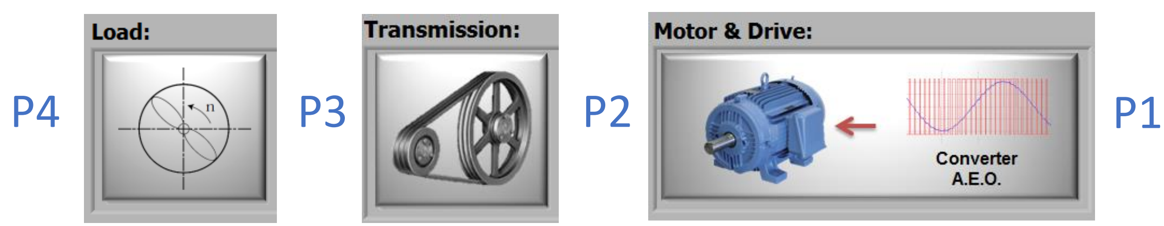


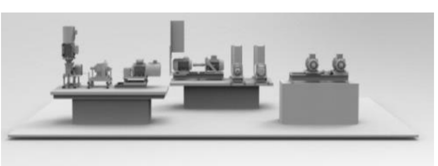


Getting started with MSTool

- Define key components (in any order)
  - Load
  - Transmission
  - Motor (+ drive)

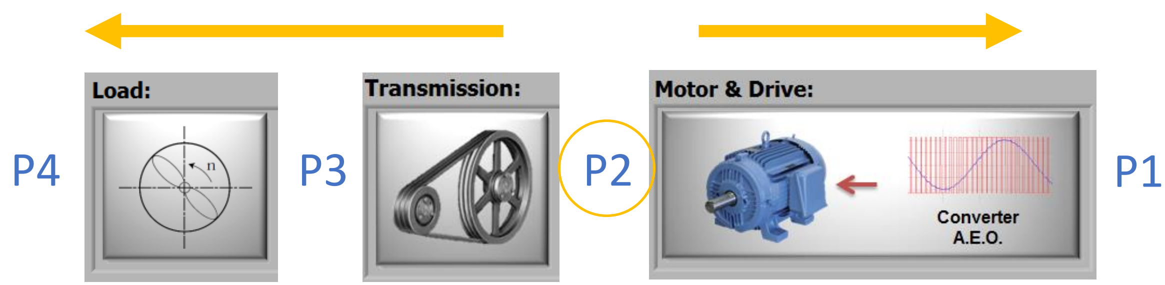
- Input known dutypoint (P1 … P4)
  - kW and speed
    - Grid
    - Shaft
    - Load input
    - Load output (e.g. fan: pressure*flow = power)

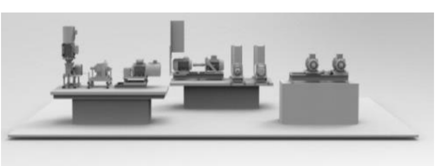




Getting started with MSTool

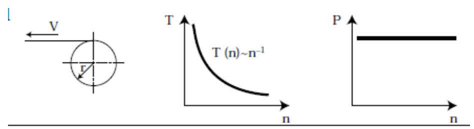
- Known duty point (P1 … P4) acts as the calculation master
  - From this point everything is calculated to the left and/or the right
  - E.g.: P2 is a known duty point (“fixed value pivot point”)



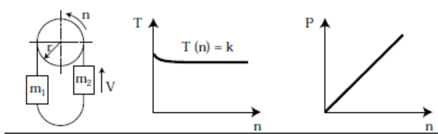


Getting started with MSTool

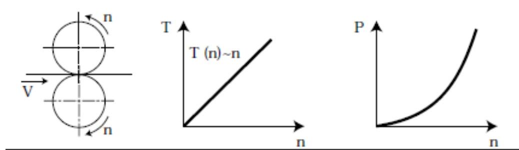
- Load: four different types (torque vs. speed)
  - Winding material under tension



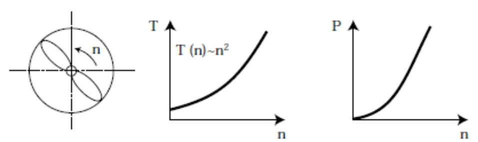
  - Conveyor belts, cranes, …

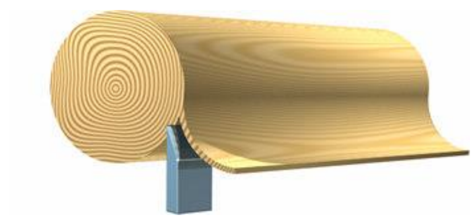


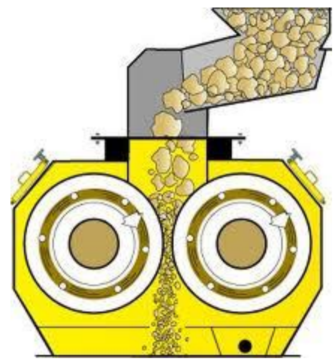
  - Rollers, …



  - Centrifugal force (e.g. pumps, fans)

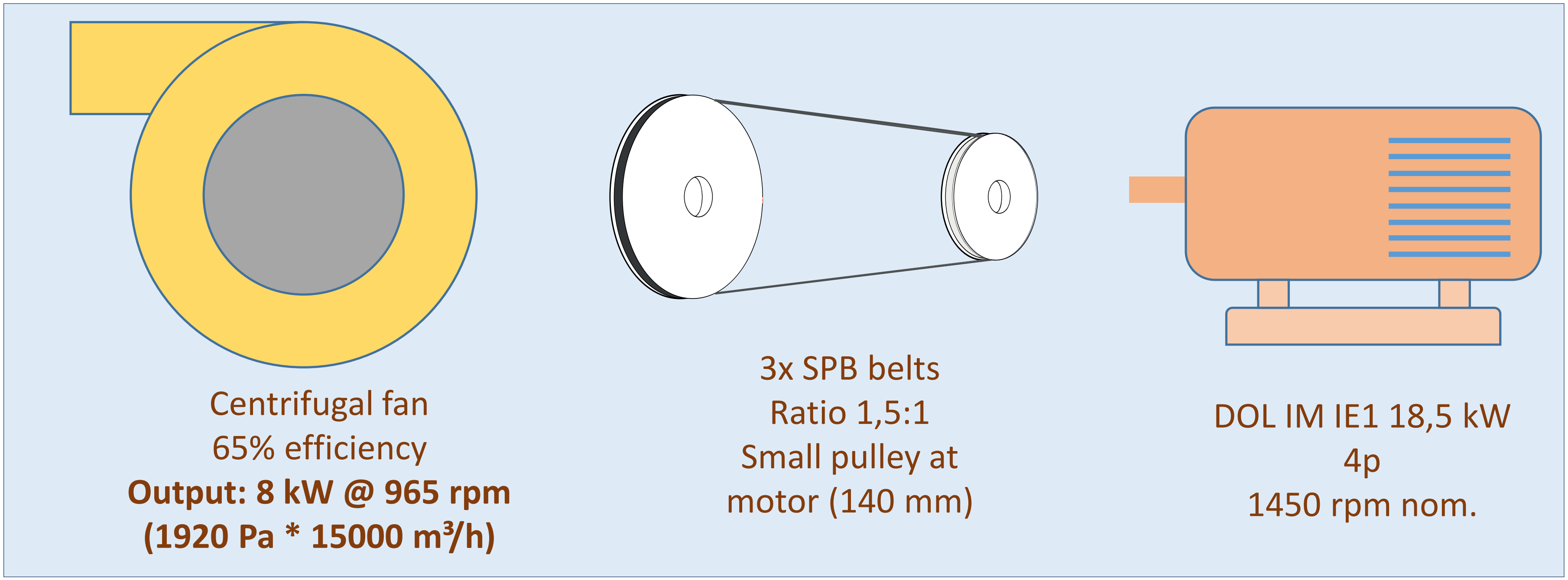






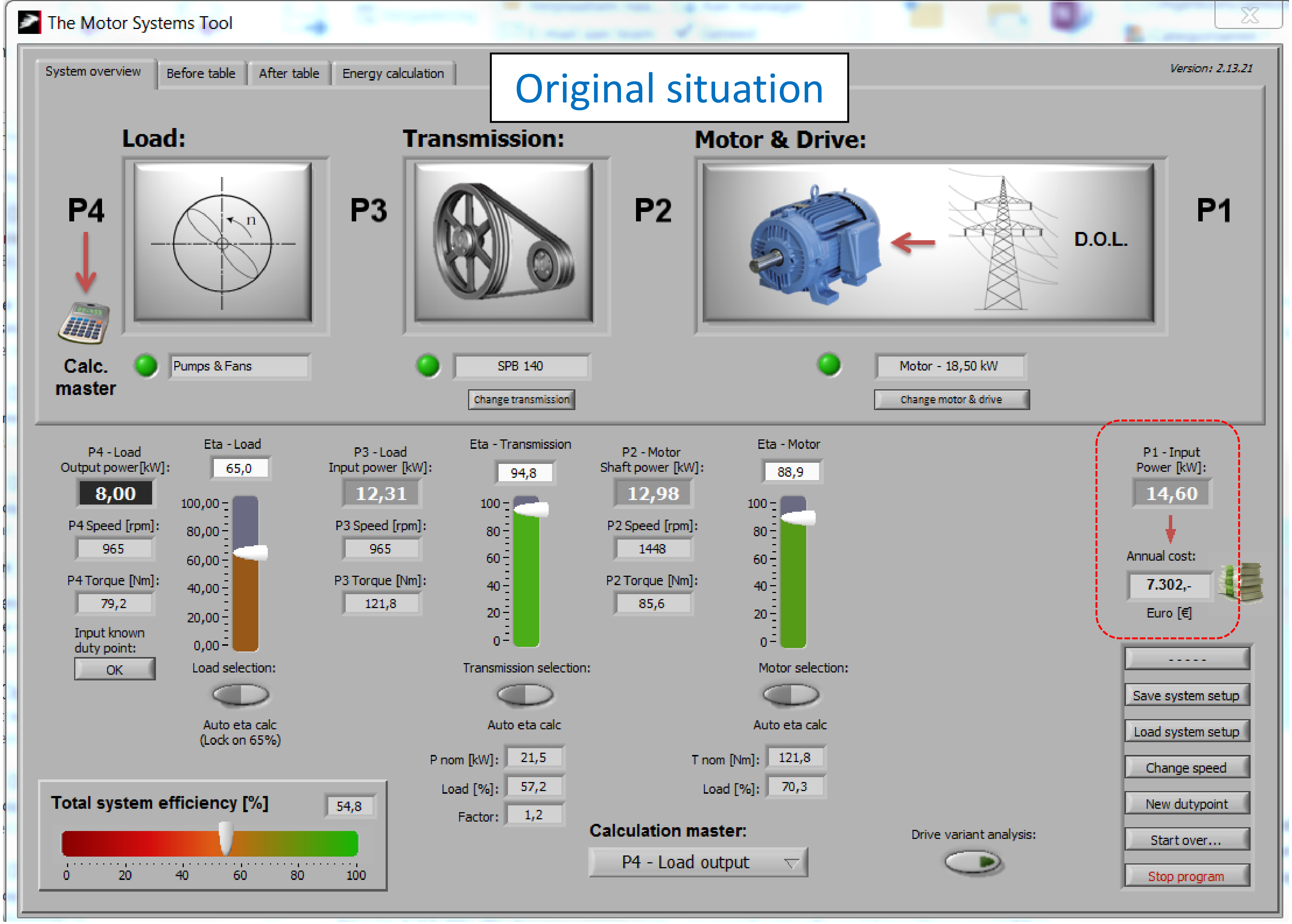
Example 1

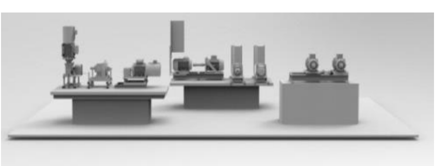
- Optimization of a dust extraction system



5000 running hours / year @ € 0,1/kWh

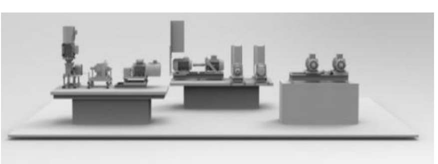
Original situation



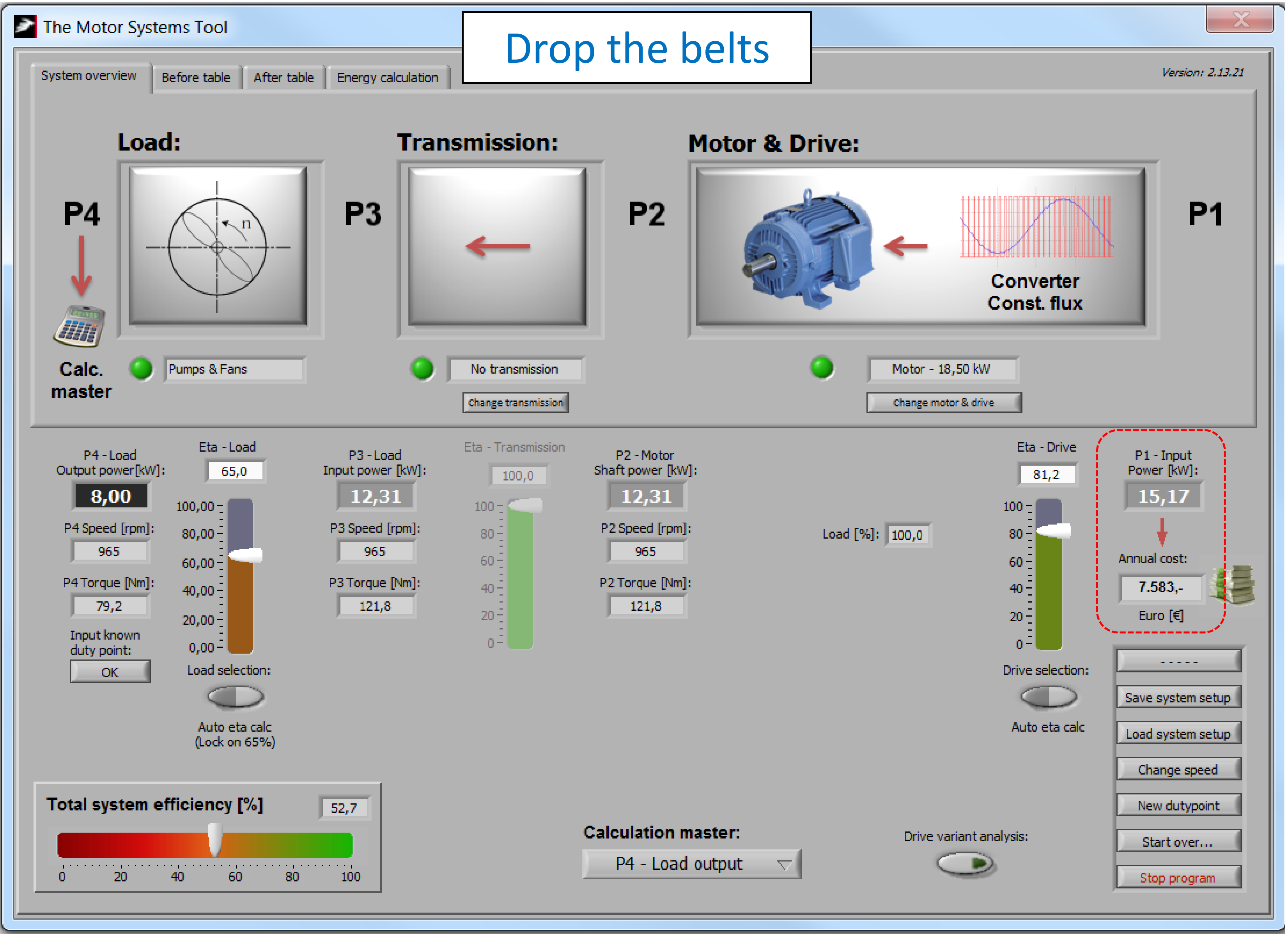


Add a drive

Total efficiency before : 54,8%



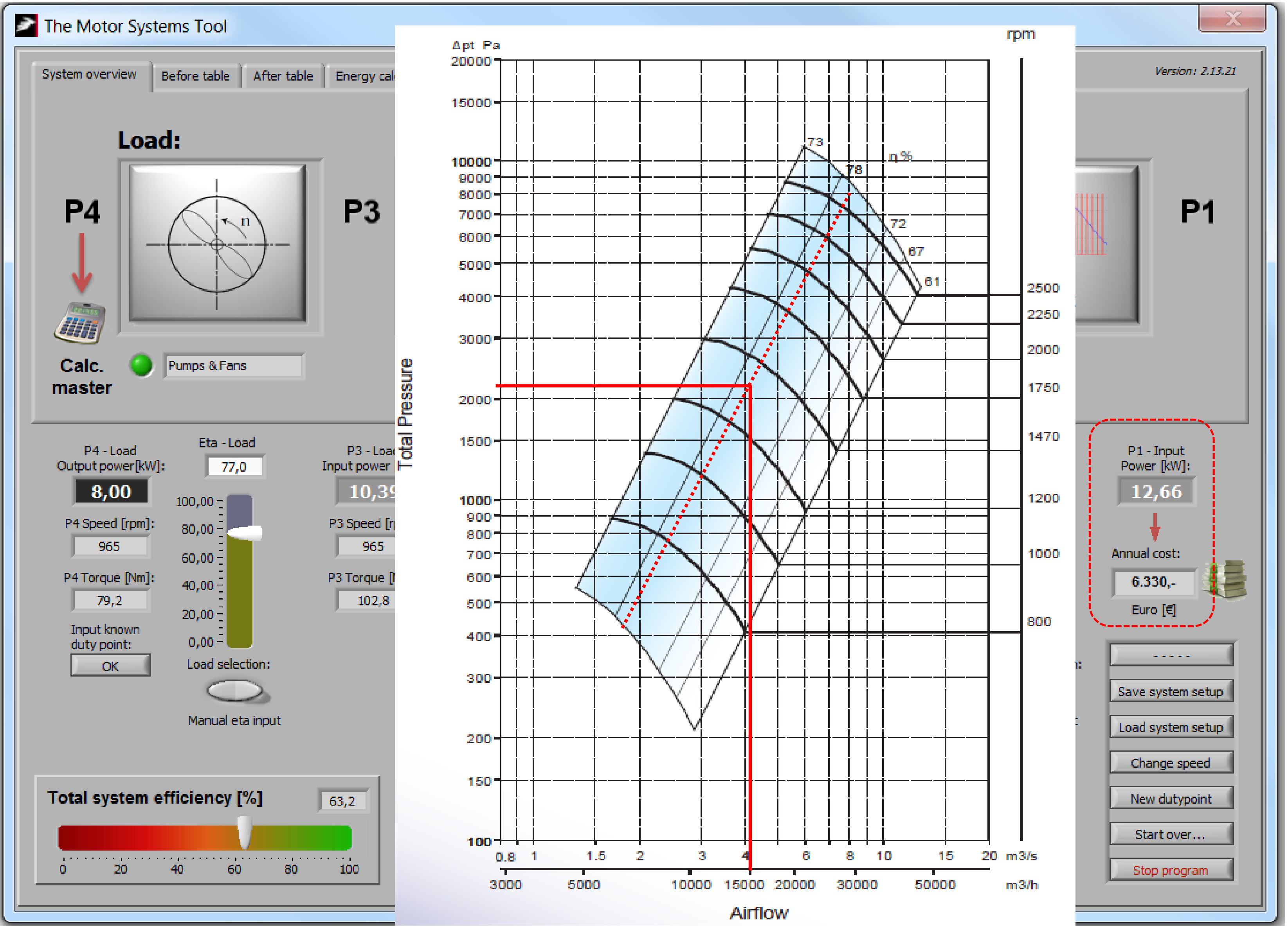
Drop the belts



Total efficiency before : 52,5%

Motor-drive efficiency before: 85,1% !

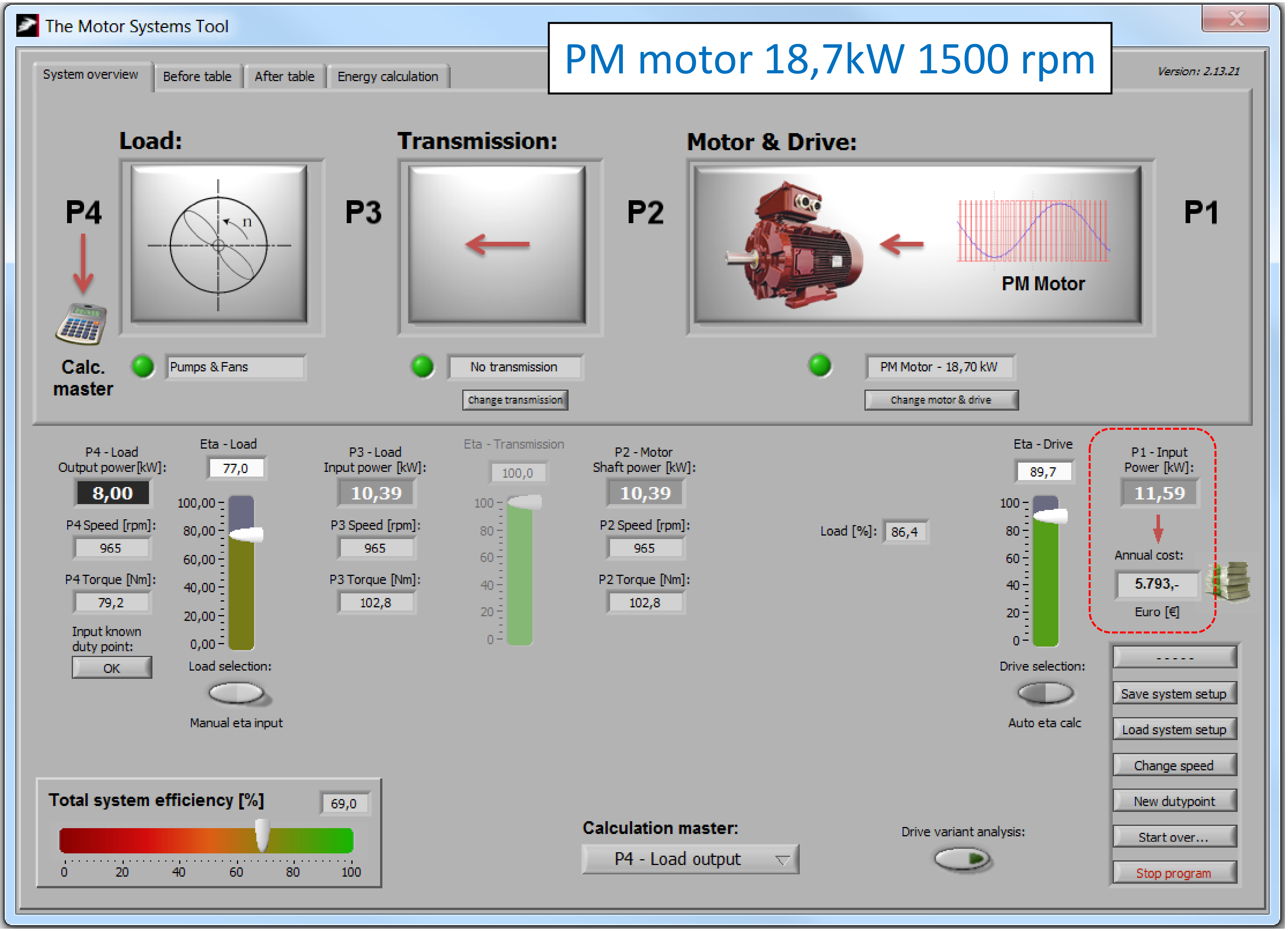
Better fan



Total efficiency before : 52,7%

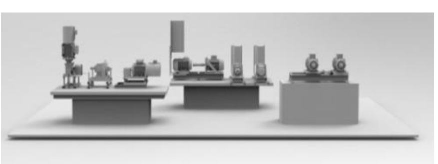
Better fan efficiency: 77% (GT550/56)

PM motor 18,7kW 1500 rpm



Total efficiency before : 62,2%

Motor-drive before: 82,1%



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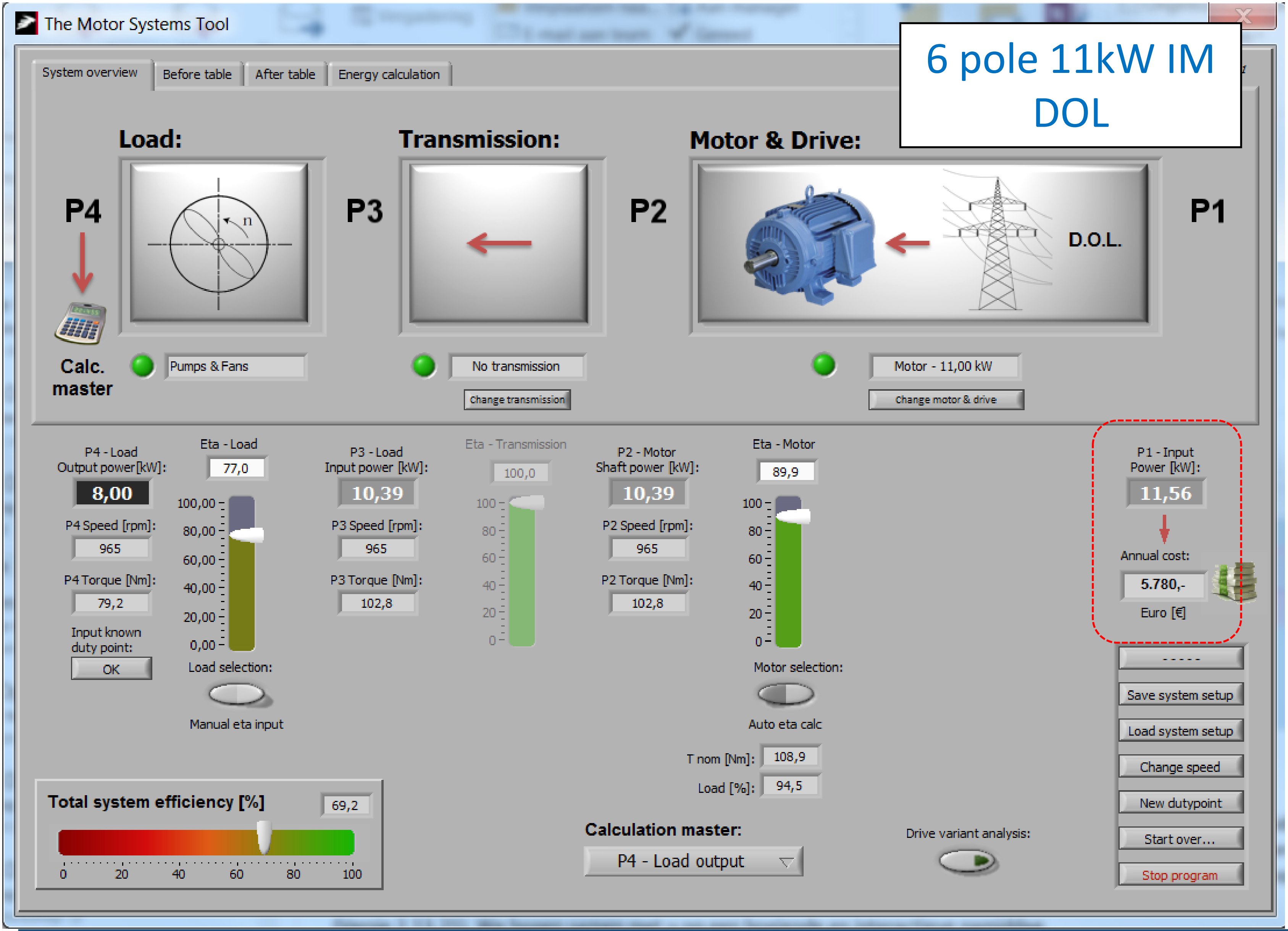
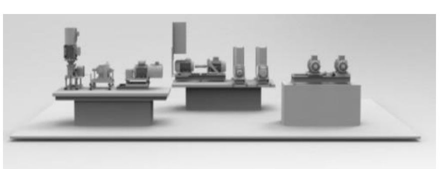
6 pole 11kW IM DOL



Total efficiency before : 69%

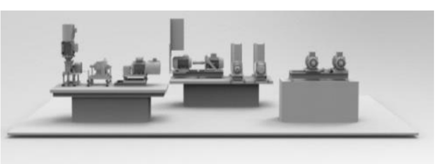
Motor-drive before: 89,7%

+ Lower cost

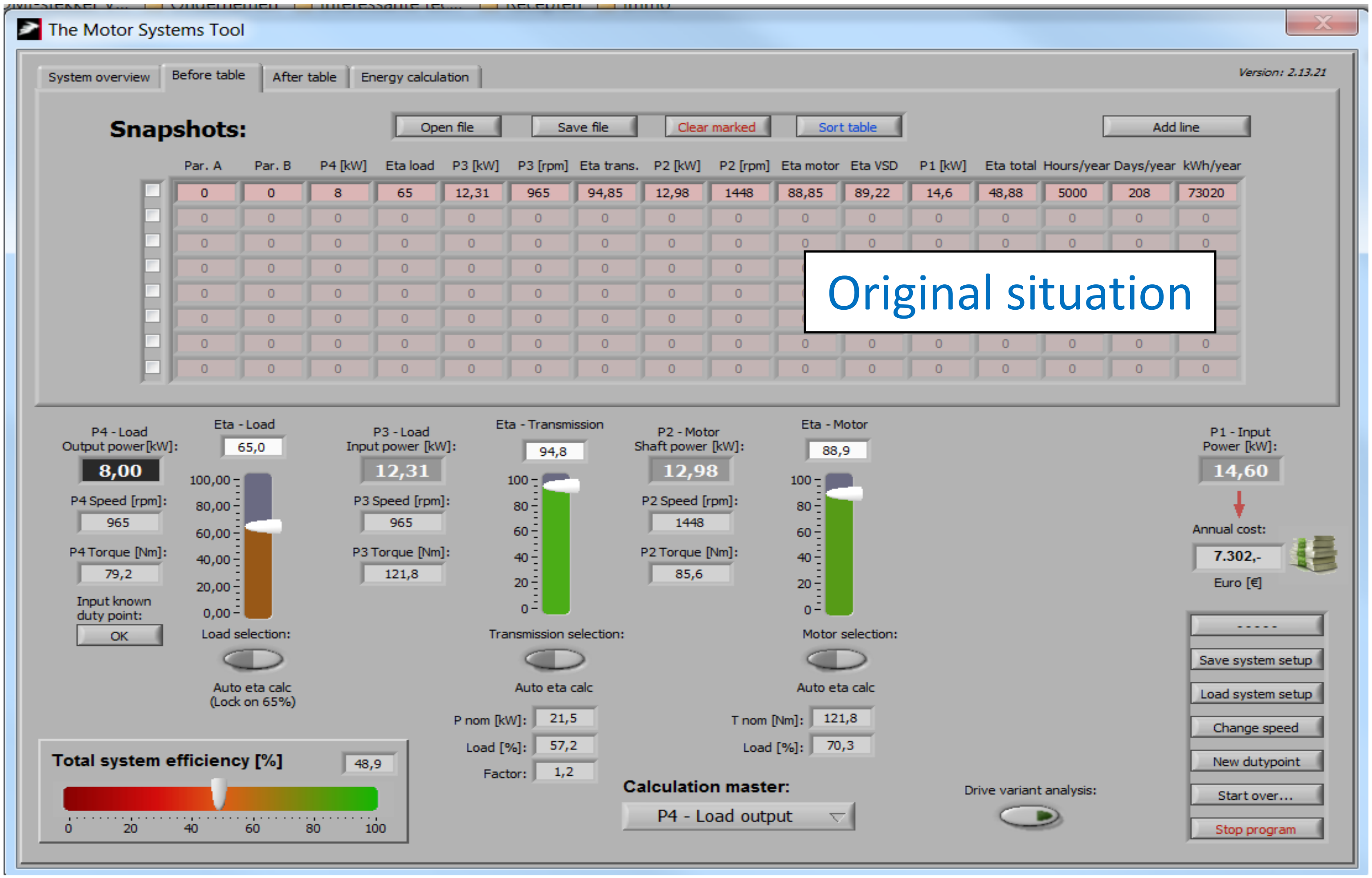


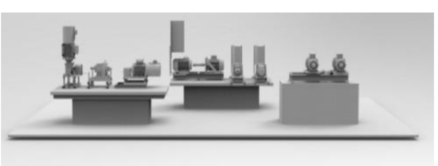
Conclusion case MSTool

- Best optimizations:
  - Optimized fan for the application
  - Omitting the belts
  - Using a 6 pole IM (synchronous speed 1000 RPM) without drive
  - Before: 14,6kWe input, after: 11,56kWe (-21%)
- Economical conclusions:
  - @ 5000h/year / €0,1/kWh
  - Before: € 7302, after: € 5780 (Δ € 1522 / year)
  - No more maintenance and stock costs on the belts
  - Useful information for future (new) installations



Use of before/after table





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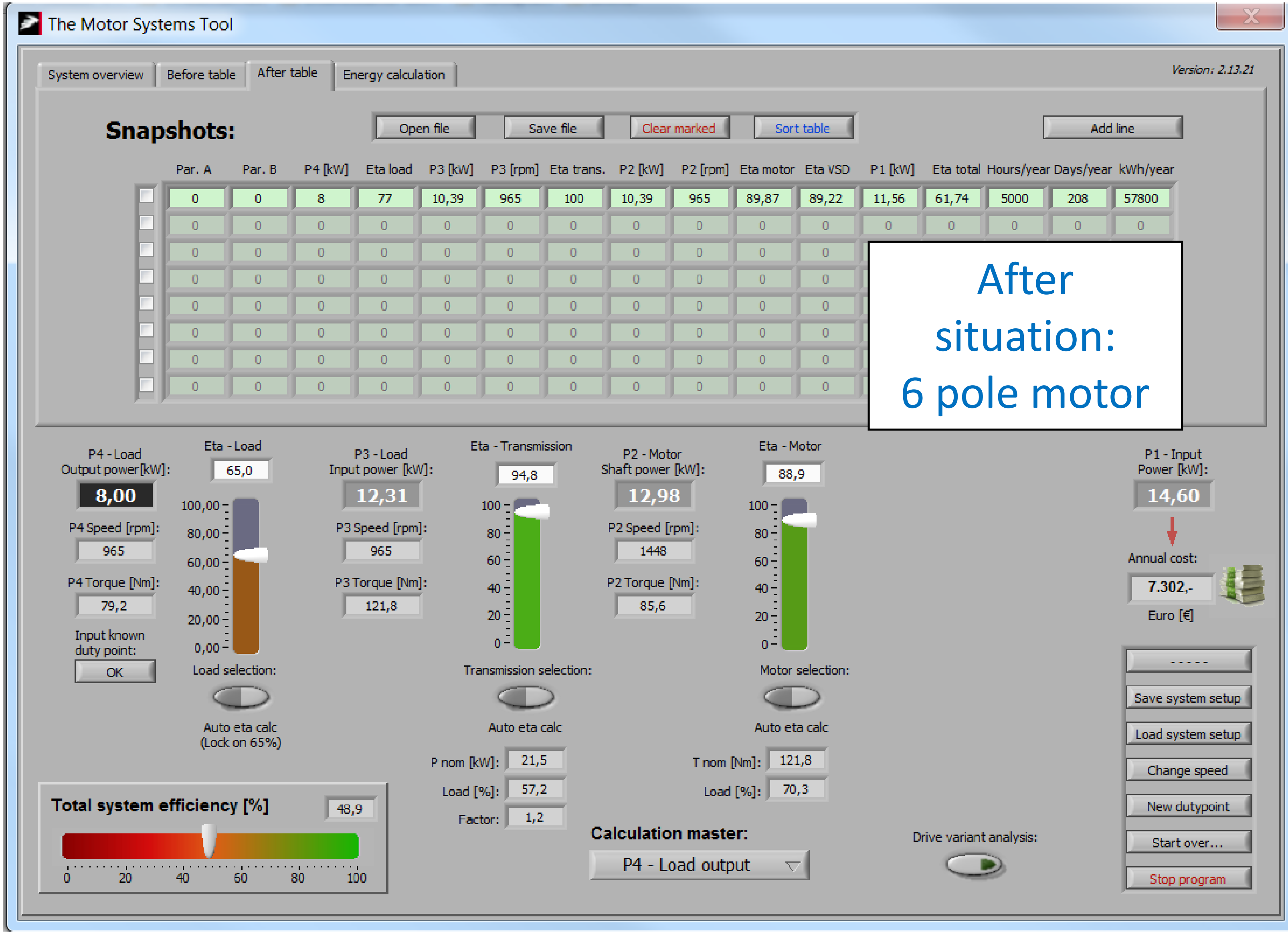

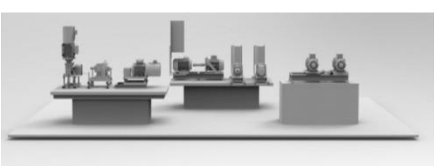

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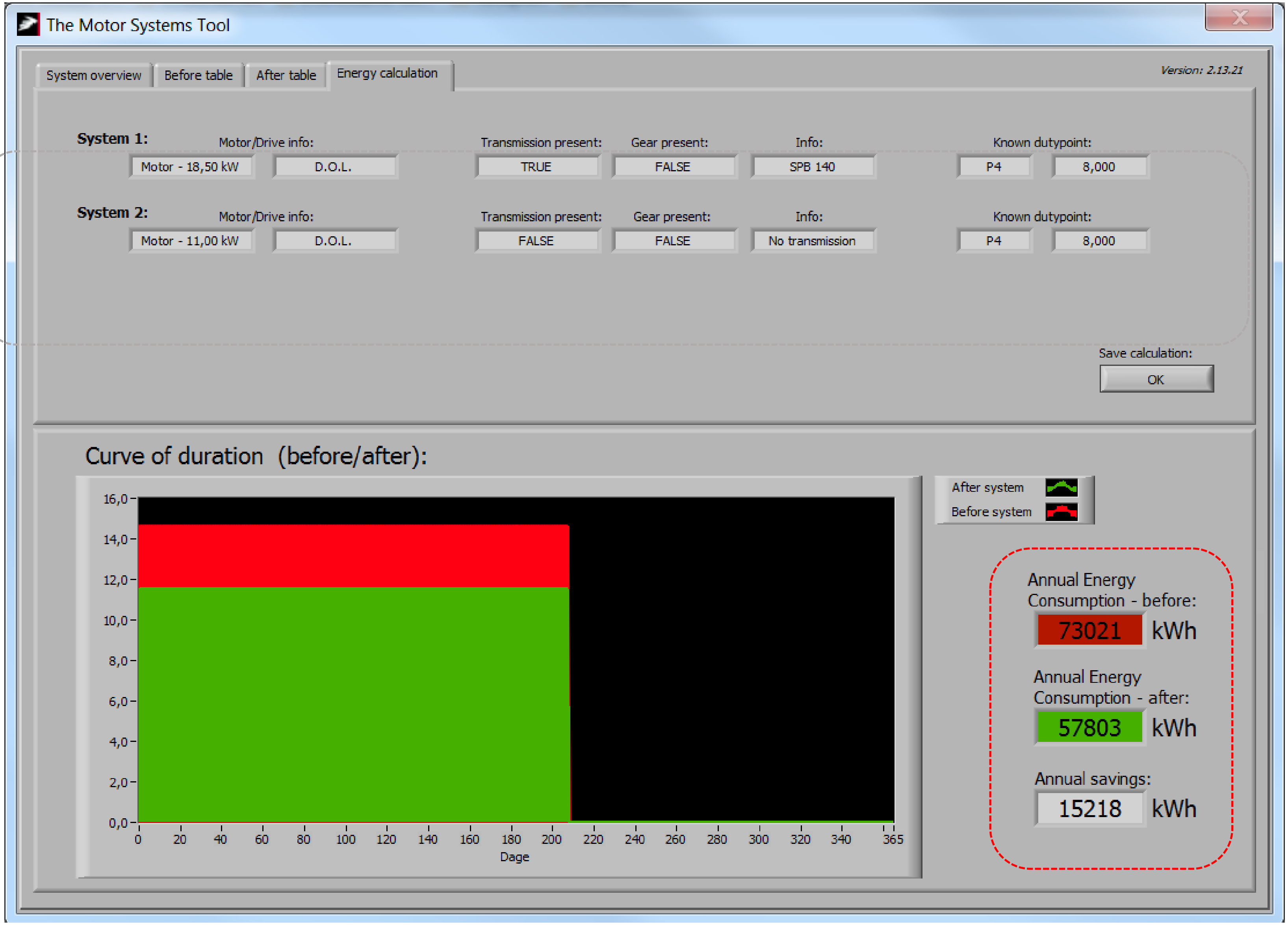
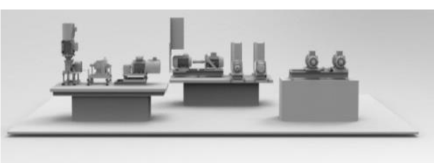
Efficiëntieverhoging Elektromechanische Aandrijvingen


The Motor Systems Tool
System overview
Before table
After table
Energy calculation
Version: 2.13.21
System 1:
Motor/Drive info:
Motor - 18,50 kW
D.O.L.
Transmission present:
TRUE
Gear present:
FALSE
Info:
SPB 140
Known dutypoint:
P4
8,000
System 2:
Motor/Drive info:
Motor - 11,00 kW
D.O.L.
Transmission present:
FALSE
Gear present:
FALSE
Info:
No transmission
Known dutypoint:
P4
8,000
Save calculation:
OK
Curve of duration (before/after):
16,0
14,0
12,0
10,0
8,0
6,0
4,0
2,0
0,0
0 20 40 60 80 100 120 140 160 180 200 220 240 260 280 300 320 340 365
Dage
After system
Before system
Annual Energy Consumption - before:
73021 kWh
Annual Energy Consumption - after:
57803 kWh
Annual savings:
15218 kWh

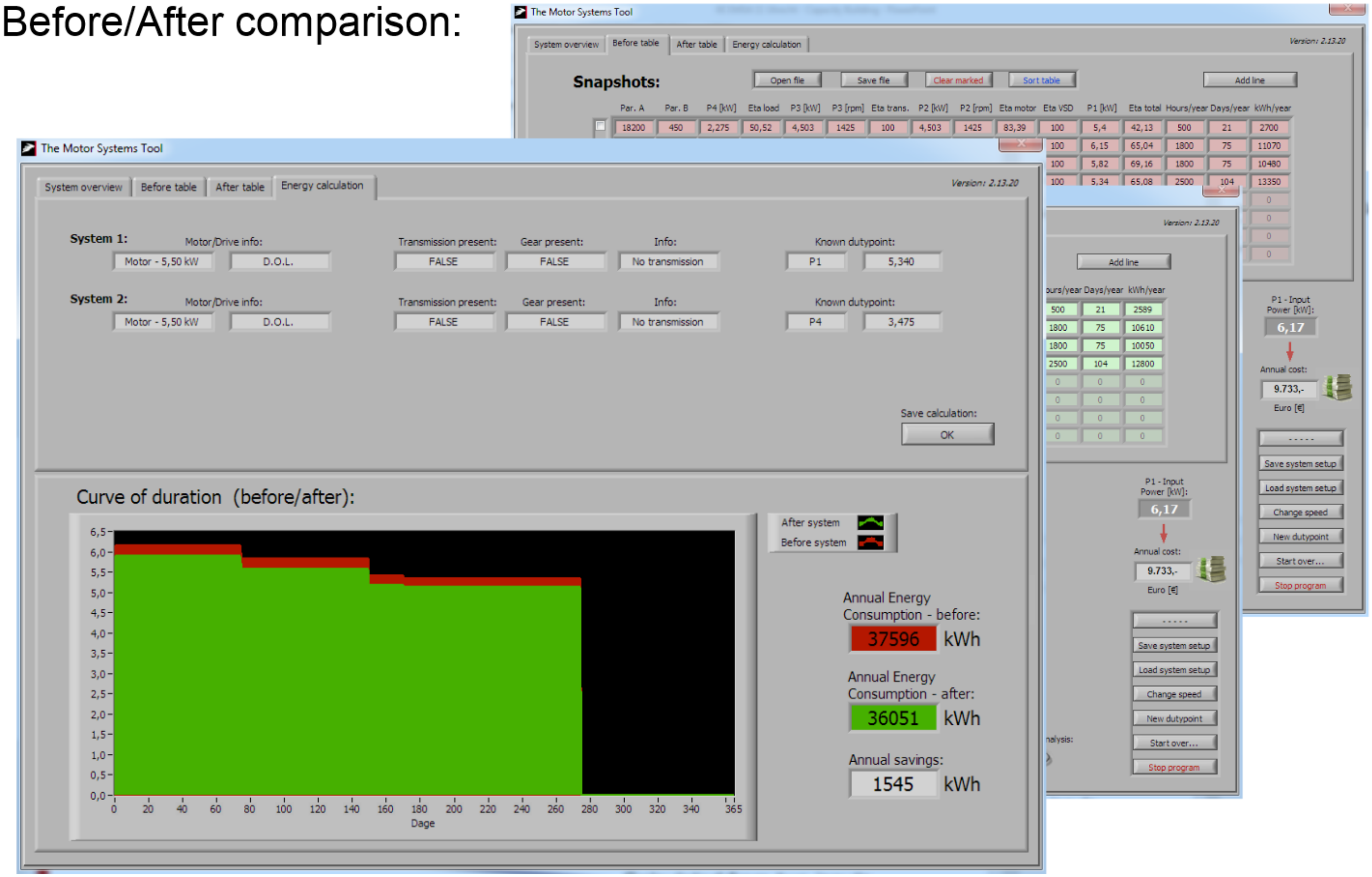
Varying load profile

- Useful for both DOL motors and drives
  - Set Calculation master at P4 → input P1 must be able to vary
- Click the “Change speed” or “New dutypoint” on the right of the screen
  - “Change speed”: for drives only
  - “New dutypoint”: for drives and DOL motors
    - e.g. a changing flow due to another position of a throttle valve (speed may or may not be changed)



Varying load profile

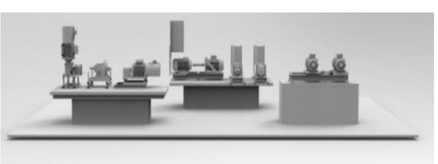
Before/After comparison:



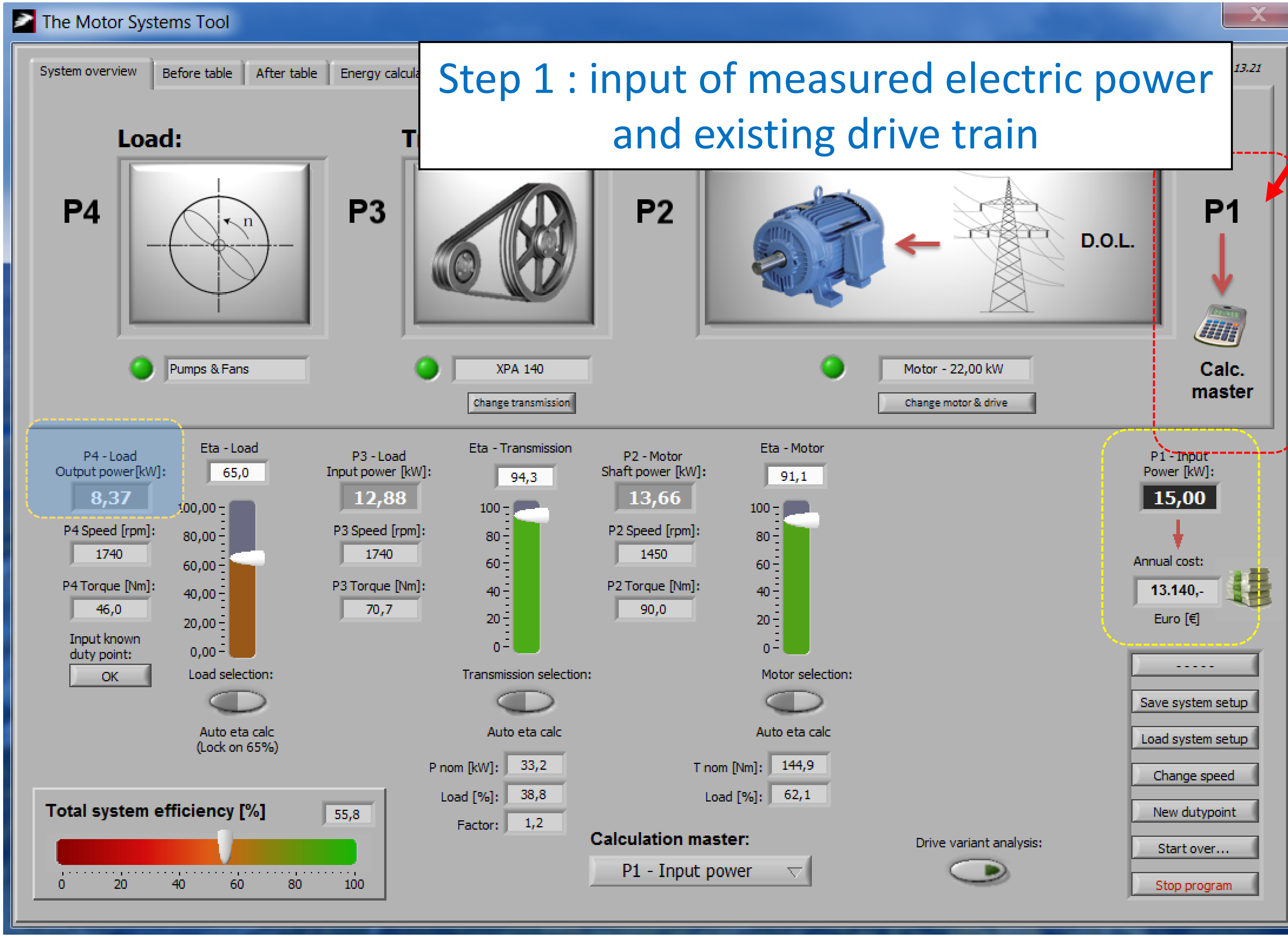
Importance of Calculation master

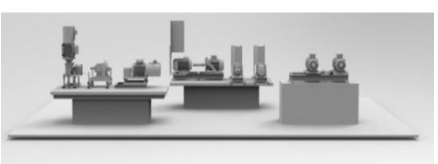
- Often P1 = electric input power is known
  - Normally most easy to measure correctly => electric measurement
- Output power (eg flow and pressure) needs to remain in new situation
- Effect on cost per year of a different drive train is to be known

=> Importance of correct use of calculation master



Step 1 : input of measured electric power and existing drive train





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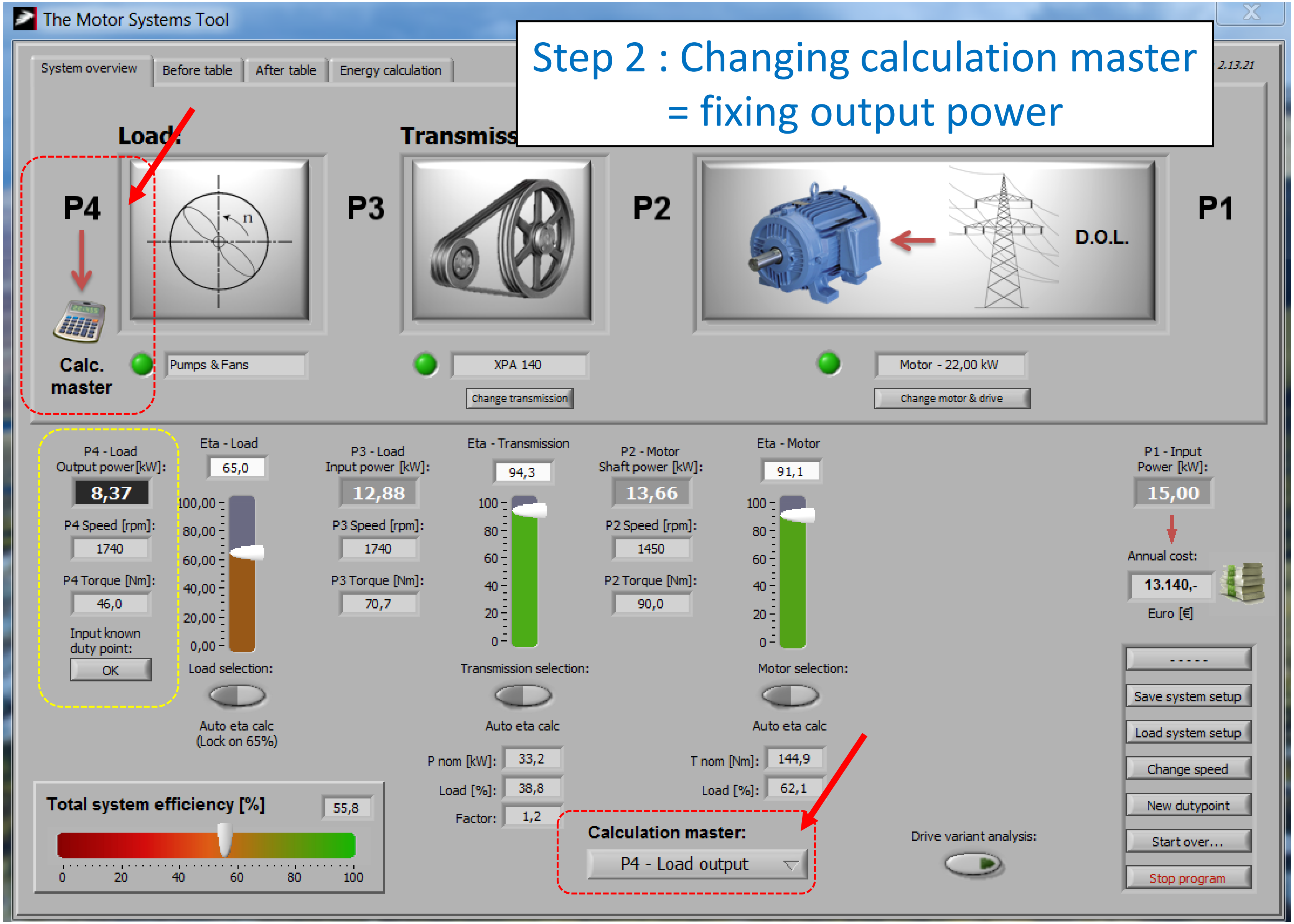
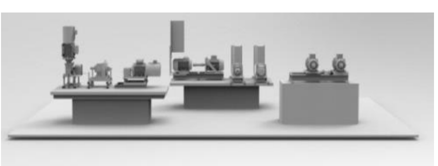
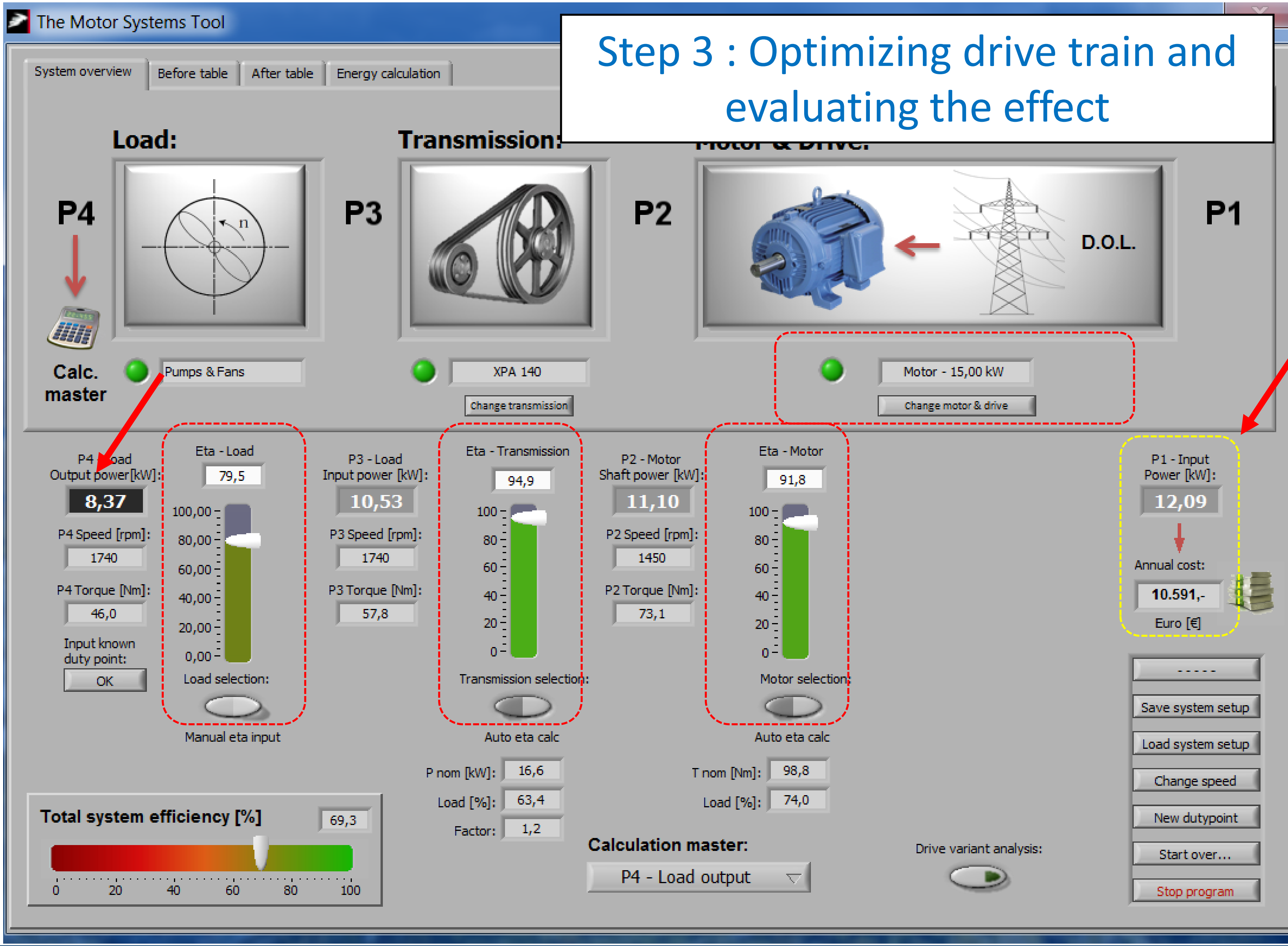
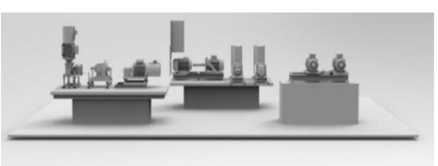
Step 2 : Changing calculation master = fixing output power





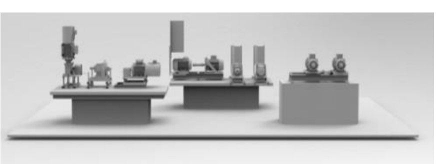
Step 3 : Optimizing drive train and evaluating the effect





MSTool and future regulation

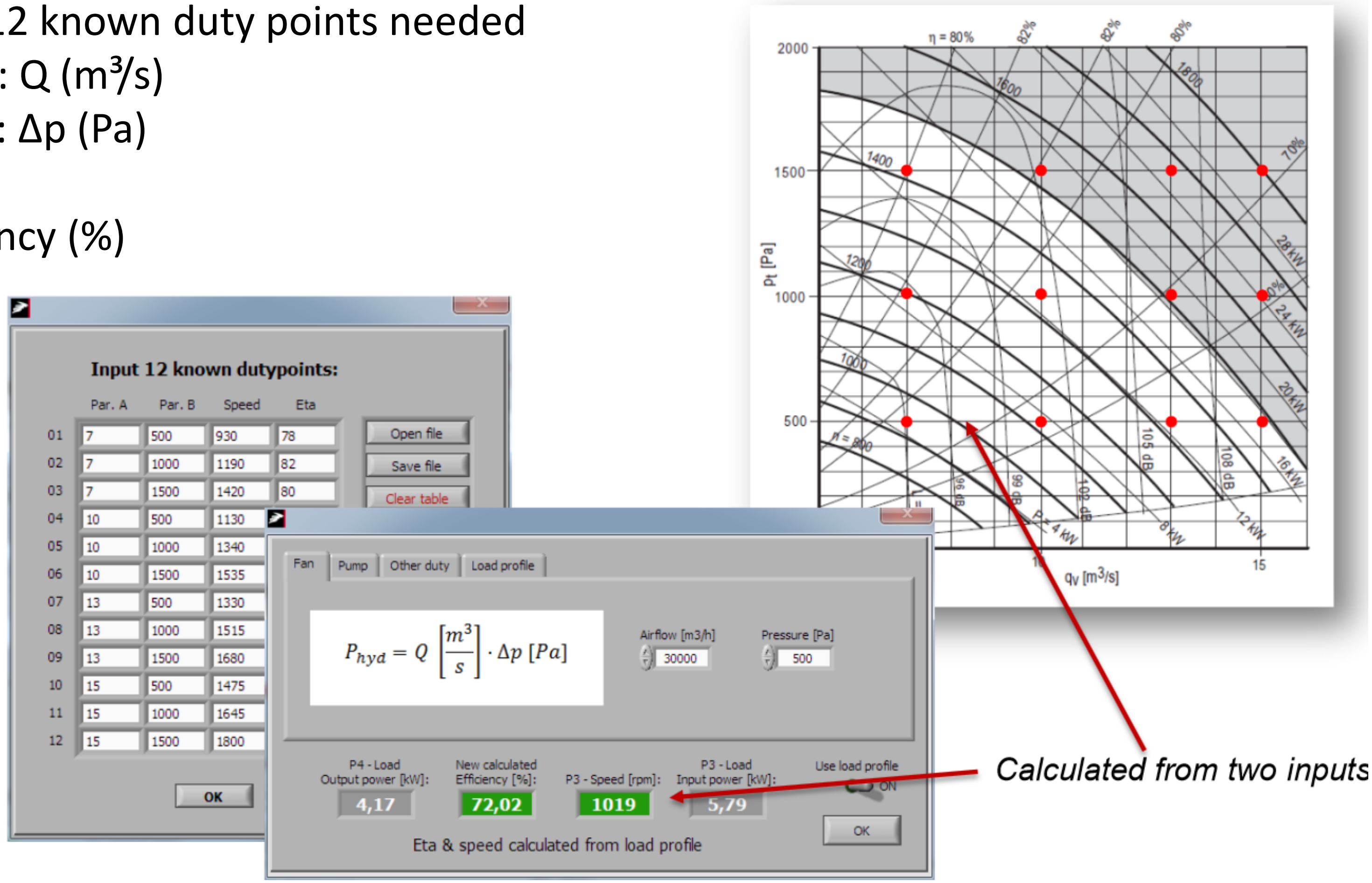
- Following EN 50598 manufacturers will need to provide data on efficiency for 8 defined torque-speed combinations
  - E.g.: 100% - 100%; 100% - 75%; ...
- MSTool allows to use this data
  - Set Calculation master at P4
  - Click: ‘Input known duty point: Ok’
  - Switch: ‘Use load profile’ on
  - Via tab ‘Load profile’ → Input data
    - Fill in 12 required points (might change, depending on final EN)



MSTool and future regulation

Input of 12 known duty points needed

- Par. A : Q (m³/s)
- Par. B : Δp (Pa)
- Speed
- Efficiency (%)



Conclusion

- MSTool gives a good indication of both total system efficiency and component level efficiency, even in partial load conditions
- Useful for existing drivetrains for new designs
- The before/after table is interesting to decide whether an investment should be made
  - Also the effect of a varying load profile can be simulated
- User input is required to enhance efficiency, as it is not a so-called smart tool
- Free download on www.ugent.be/studiedagesmads