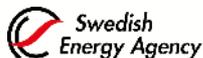




UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION
Progress by innovation



End-user Webinar





Agenda

Intro to EELA

Introduction to motor efficiency

Top energy saving measures in motors system

How to calculate savings

Q&A

How to practically improve motor efficiency in your factory

Evaluation

Closing



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ENERGY EFFICIENCY FOR LIVELIHOOD SUSTAINABLE IN AFRICA

EELA SEEKS TO PROMOTE INCLUSIVE AND SUSTAINABLE ECONOMIC GROWTH THROUGH INTEGRATED ENERGY EFFICIENCY INTERVENTIONS.



Accelerating the uptake of high-performing affordable, and energy-efficient appliances



Increasing energy efficiency investments in the industrial sector



Promoting sustainable local value chains for energy-efficient products and services.

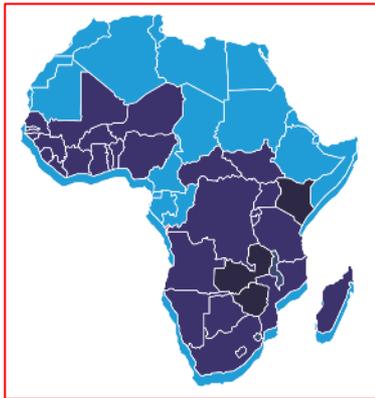
EELA contributes to a **low-carbon, climate-resilient** and **environmentally sustainable economy** and responds to the priorities of the countries NDCs and development goals.



PROGRAM COVERAGE

EELA INCLUDES REGIONAL INTERVENTIONS IN THE ECOWAS, EAC AND SADC REGION AS WELL AS MULTIPLE EELA COUNTRY WINDOWS (KENYA, ZAMBIA, ZIMBABWE).

Implemented by UNIDO with financial support from the Government of Sweden:





DEVELOPMENT IMPACT



- Contribute to poverty reduction through **improved access to energy sustainable energy services** for women and men, girls and boys
- **Mitigate negative externalities** of the energy system
- **Reduction** of household expenditures and **energy costs** for businesses
- Enhanced deployment of **productive use equipment** to improve livelihoods and reduce post-harvest losses through efficient on/off-grid cooling and agro-processing equipment



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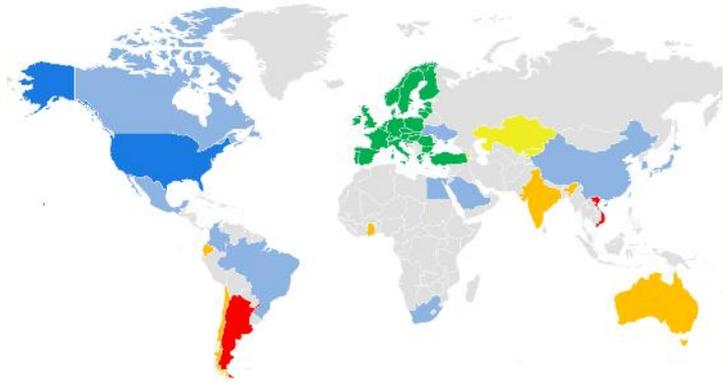
How to practically improve motor efficiency in your factory

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Energy saving in motor Systems

- Motors consume about 70% of electricity consumption in industrial facilities
- Savings of about 20% to 30% can typically be achieved in factories, with most factories easily saving 15%
- Governments promote EE motor use through awareness campaigns
- MEPs is the main theory to encourage such transitions

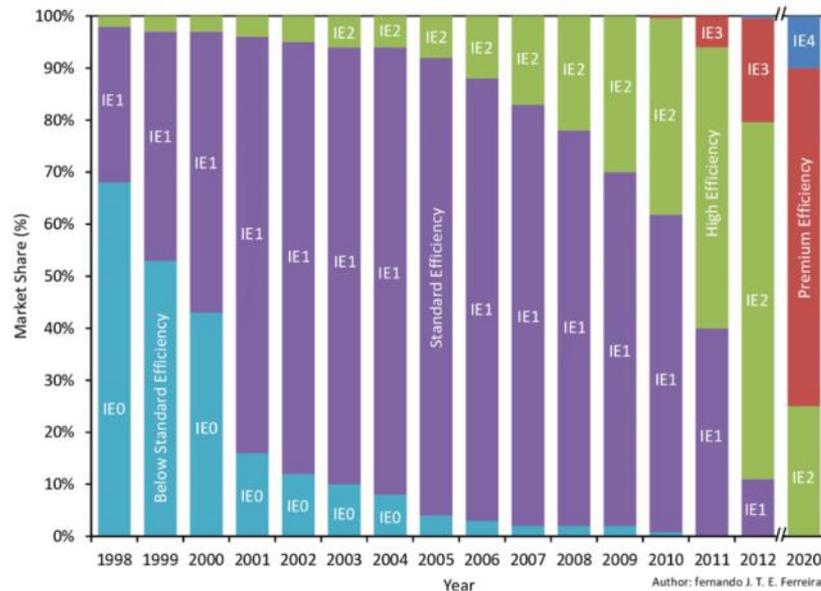


Motors efficiency is mapped
through IE standards

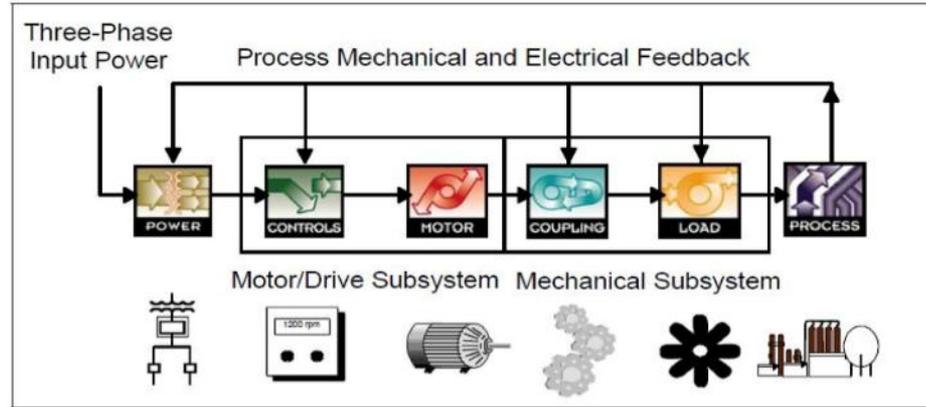
IE1 < **IE2** < **IE3** < **IE4** < **IE5**
IE4

Rapid shift towards high efficiency motors

- The world has been moving towards shifting to higher-efficiency motors
- As a rule of thumb, for each IE level up, you save about 15% to 30%
- The installed base in Africa is likely around IE1 mostly
- How fast would it take us to shift to IE3

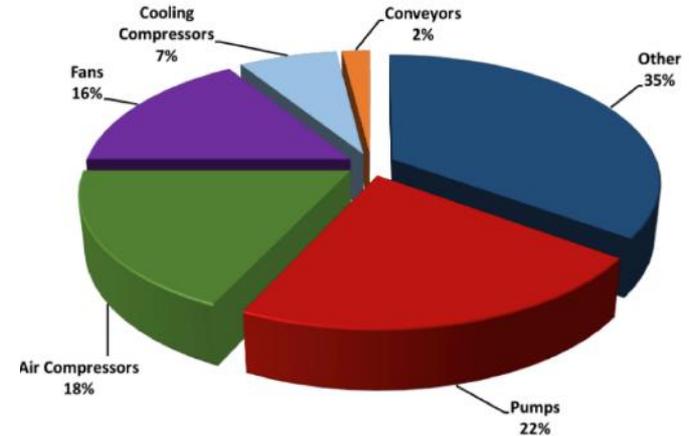


Energy saving in motor Systems



$$\eta_{system} = \eta_{VSD} \cdot \eta_{motor} \cdot \eta_{transmission} \cdot \eta_{end-use} = \frac{P_{useful}}{P_{input}}$$

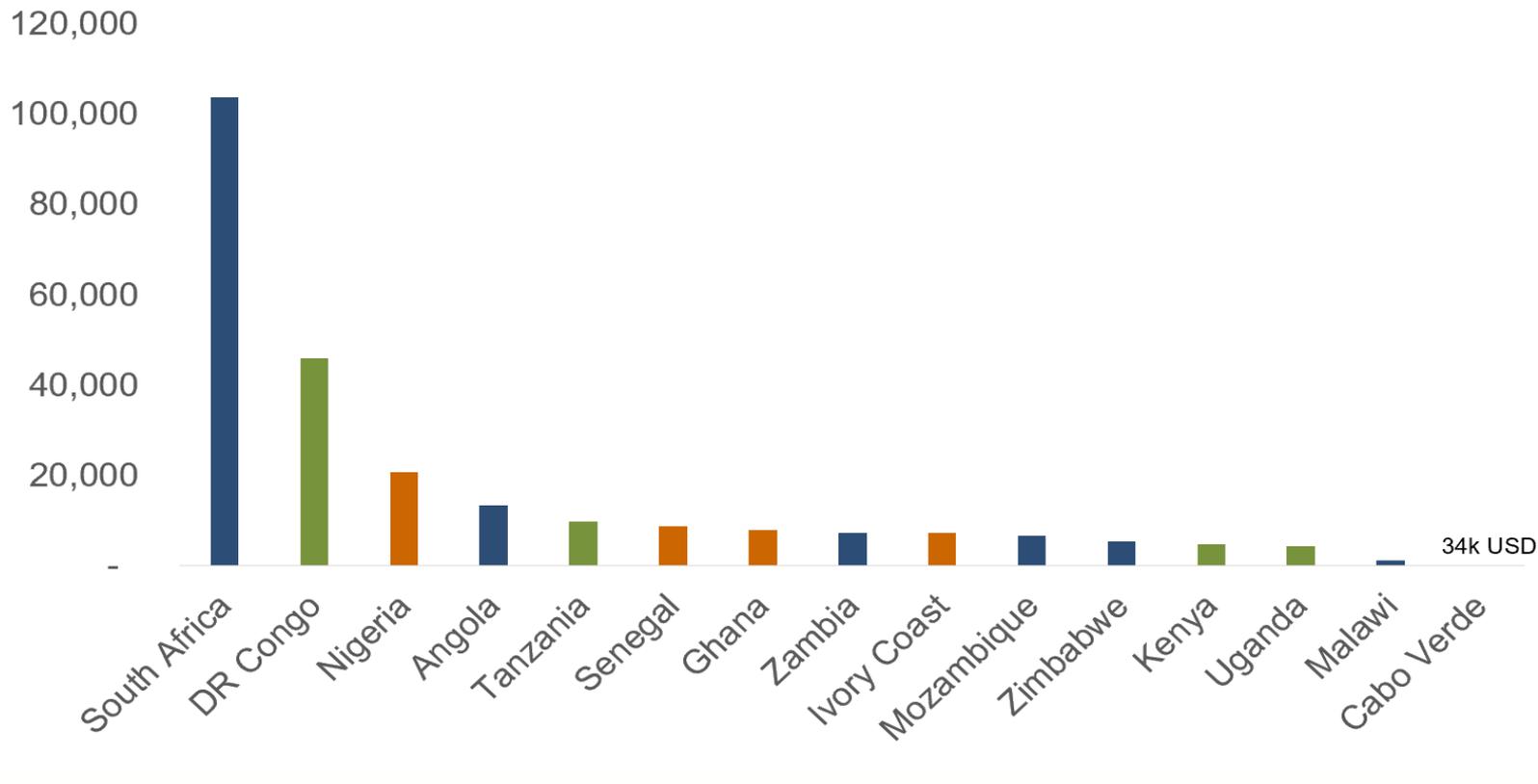
Motor Systems Electricity Consumption by Application



Electricity Consumption in the European Union Industrial Sector
Source: ISR – University of Coimbra (2012)

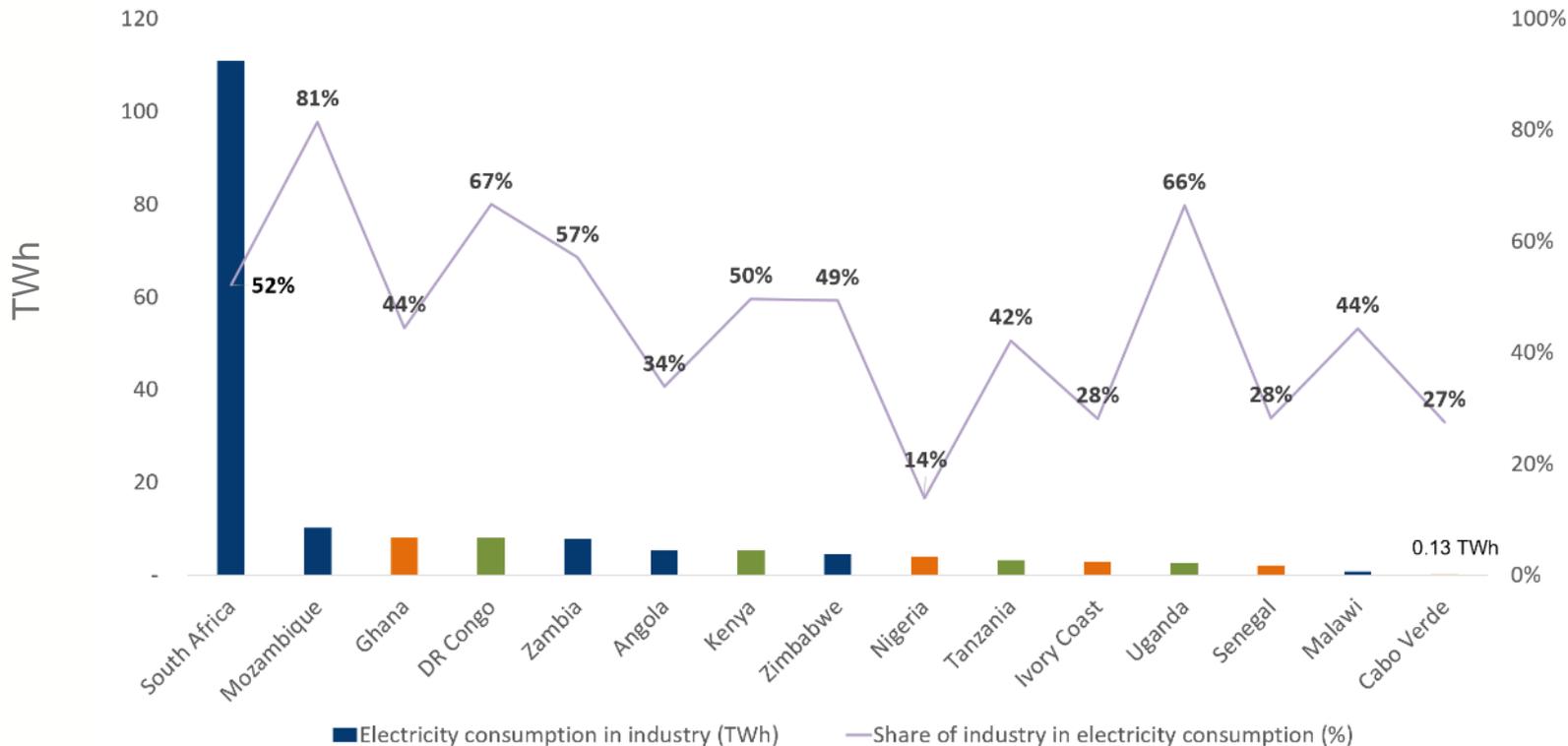
Motor market exceeds USD 250 million (1-100 HP)

Import value of motors in 2023 (1000 USD)



Industry consumes 46% of electricity on average

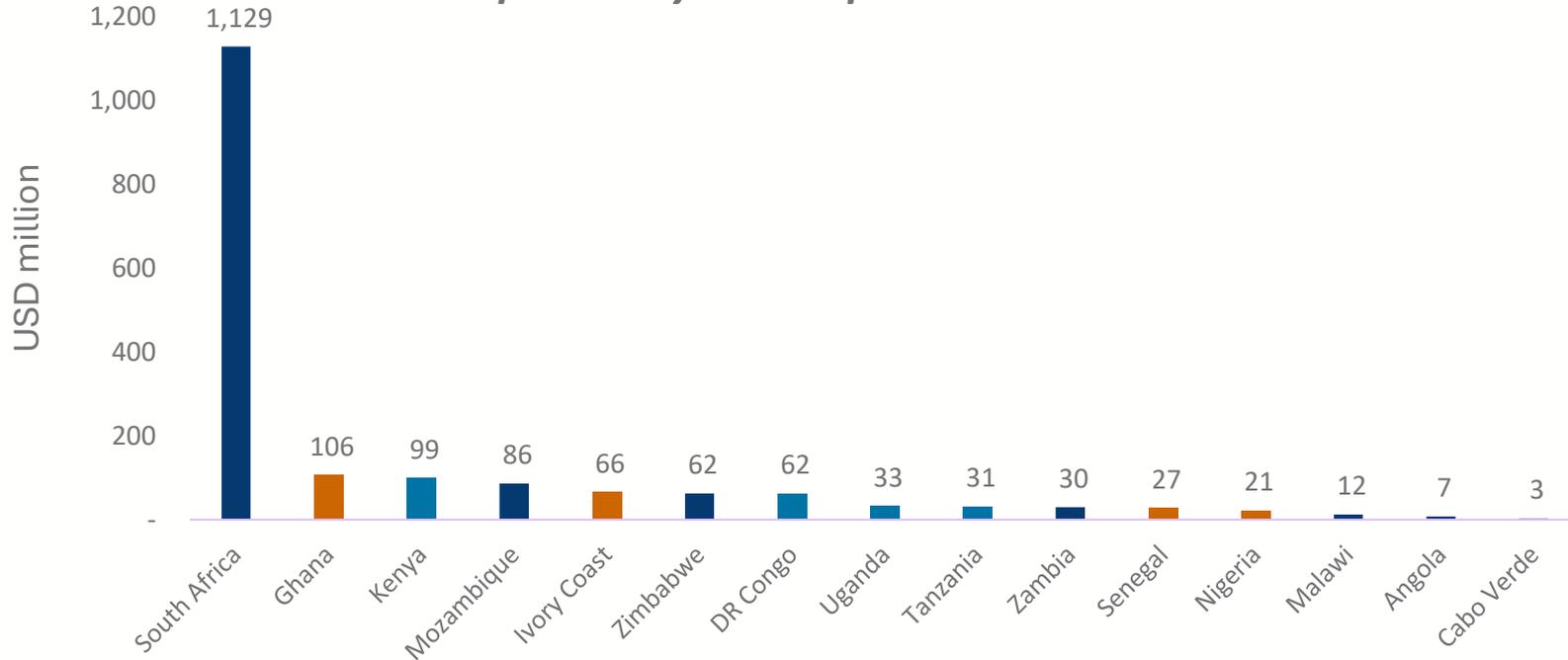
Electricity consumption in industry vs % of overall consumption





About USD 1.5 billion can be saved per year

Potential savings for industry (million USD) per year if efficiency is improved by one step in IE standards



SADC

ECOWAS

EAC



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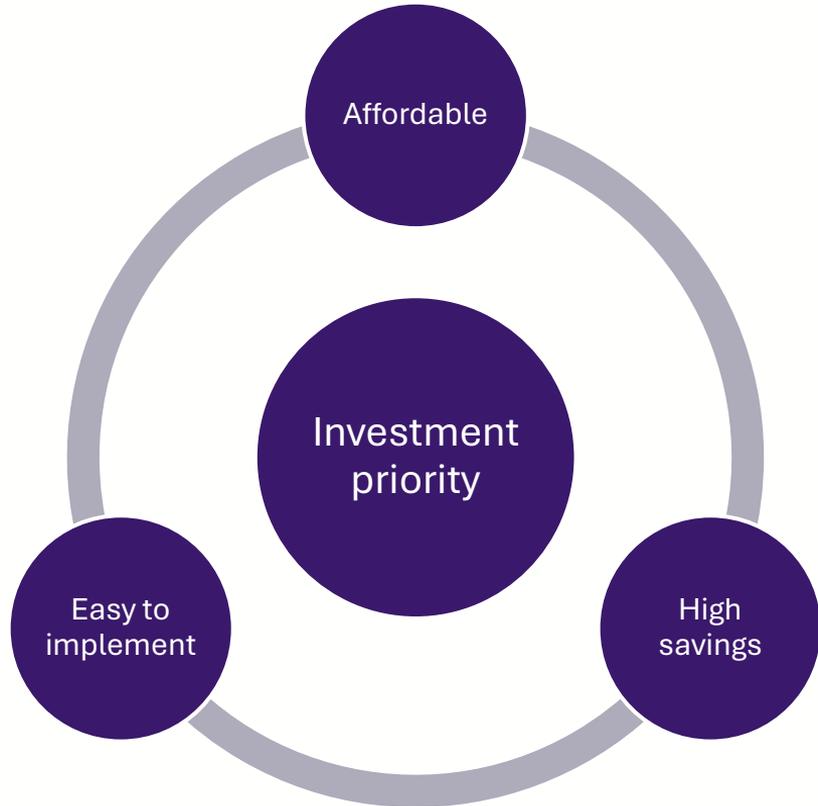
How to practically improve motor efficiency in your factory

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Top 10 savings opportunities in your facility



VSD to adjust water flow in pumping systems - 1



Saving

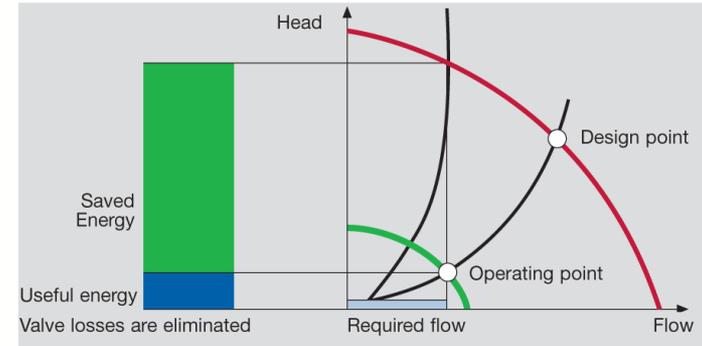


Affordability



Ease

- ✓ VSD should be used for pumps operating between 20% and 80% of its rated power
- ✓ Can save up to 80% in energy use



Using proper coupling elements - 2



Saving

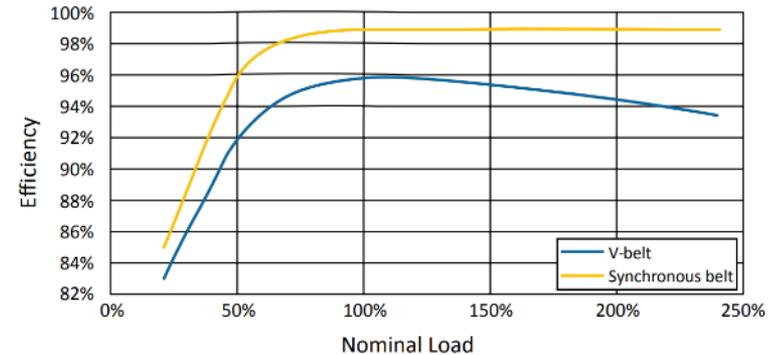
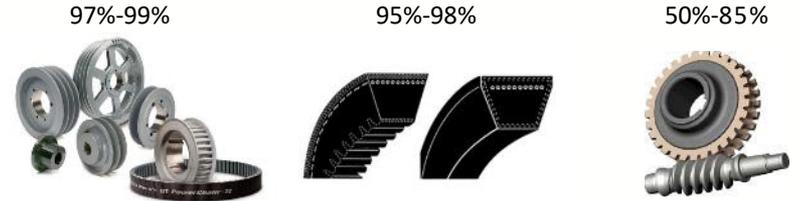


Affordability



Ease

- ✓ 1% improvement in coupling element
- ✓ Saves USD 180 per year in 100 HP motor at 1 shift of operations



Adjusting coupling elements - 3



Saving

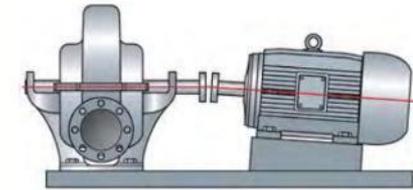


Affordability

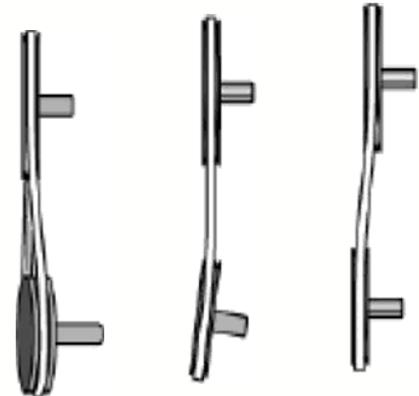
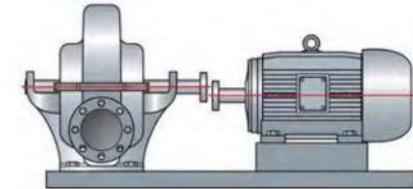


Ease

- ✓ Major losses that can be avoided at minimal investments
- ✓ Misalignment can easily lead to 4%-5% efficiency loss
- ✓ It leads to more frequent failure



b)



Balancing voltage - 3



Saving

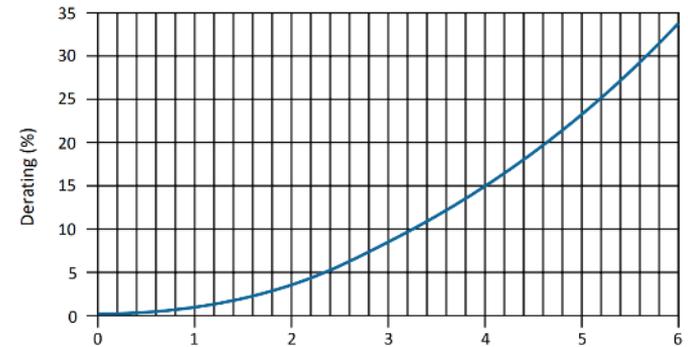


Affordability



Ease

- ✓ Major losses that can be avoided at minimal investments
- ✓ Misalignment can easily lead to 4%-5% efficiency loss
- ✓ It leads to more frequent failure



$$\%VU = \frac{\text{max. voltage deviation from the avg. voltage}}{\text{avg. voltage}} \times 100$$

Balancing voltage - 3



Saving

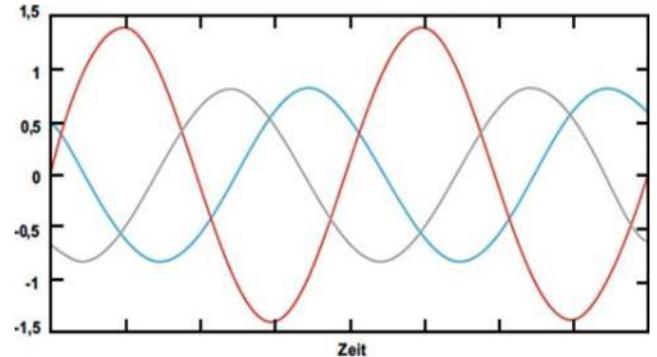


Affordability



Ease

- ✓ If imbalance is 3.6% then about 2% efficiency reduction takes place
- ✓ USD 360 per year (100 HP, 1 shift)



Coordinating motor groups - 4



Saving



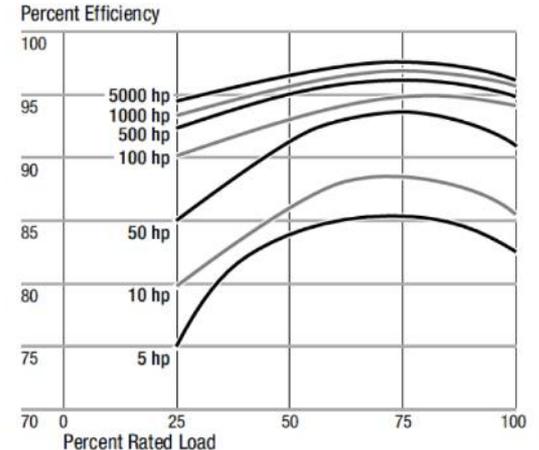
Affordability



Ease

- ✓ Coordinating motors (in pumps, compressors and chillers) improves their overall efficiency
- ✓ Motors operating in load sharing without coordination can be operating outside the optimum efficiency load
- ✓ Coordination takes place through automation or dedicated controllers (sequencers, integrated pump controllers, etc.)

Rapid loss of efficiency takes place in under and overloading



Optimization of compressors - 5



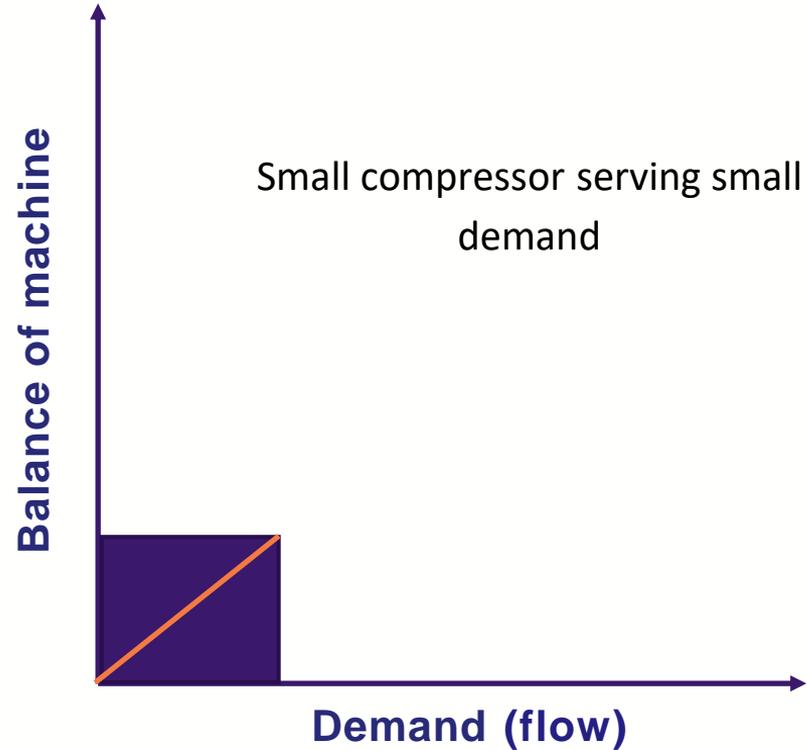
Saving



Affordability



Ease



Optimization of compressors - 5



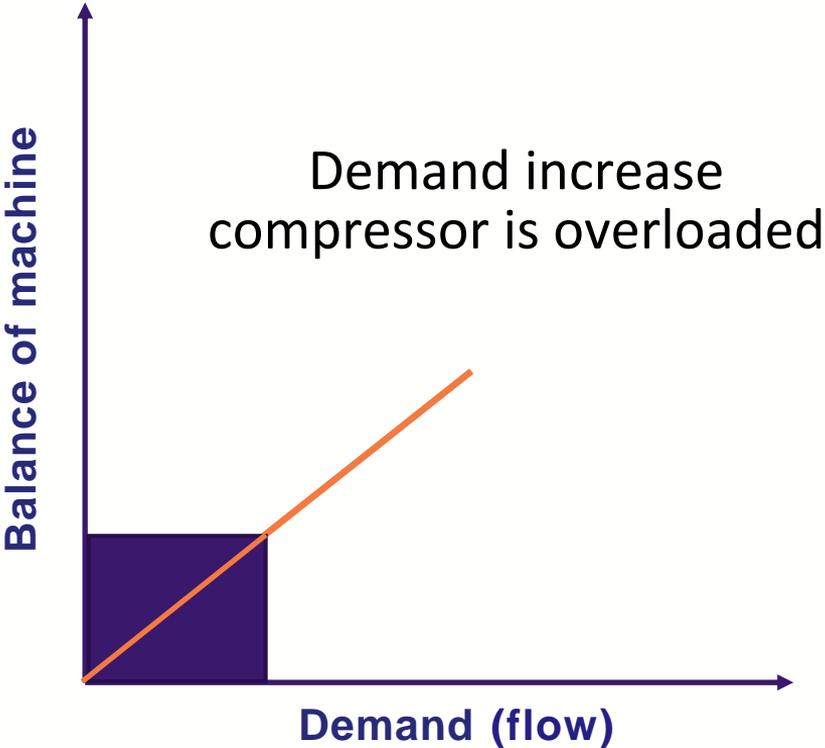
Saving



Affordability



Ease



“Manual for INDUSTRIAL MOTOR SYSTEMS ASSESSMENT AND OPTIMIZATION, UNIDO, 2018”
“Industrial Motors Efficiency Programme (IMEP) Egypt, UNIDO, 2020-2025”

Optimization of compressors - 5



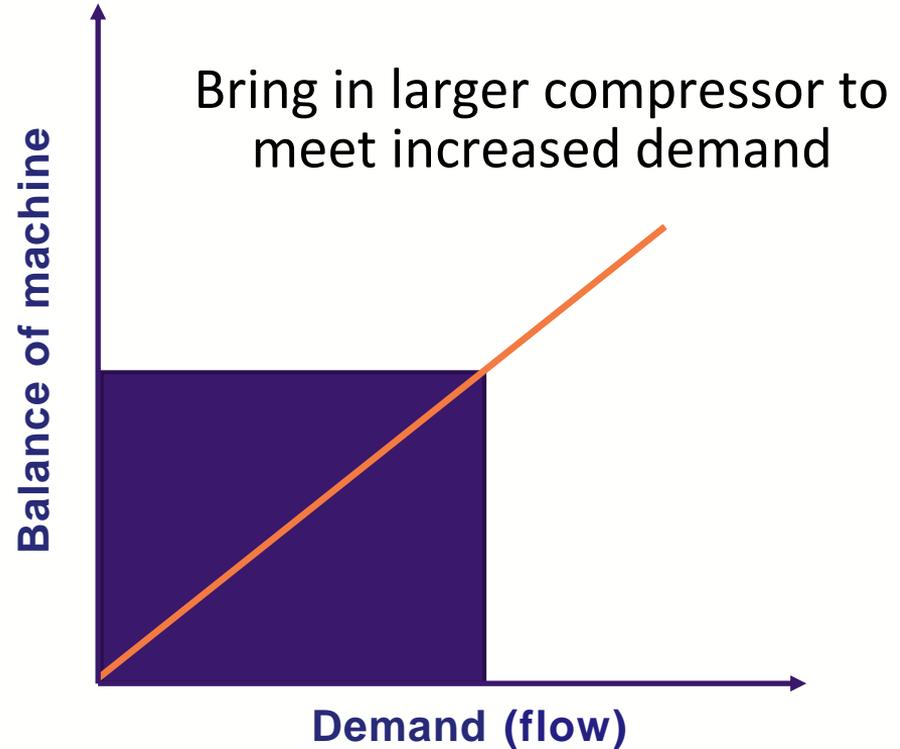
Saving



Affordability



Ease



Optimization of compressors - 5



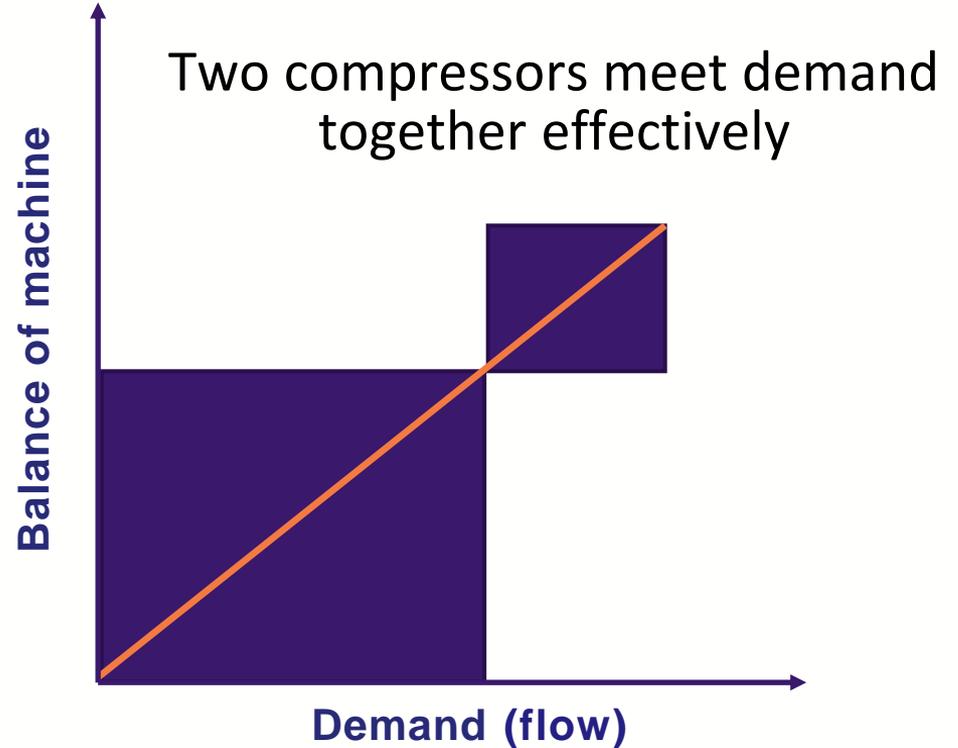
Saving



Affordability



Ease



Optimization of compressors - 5



Saving

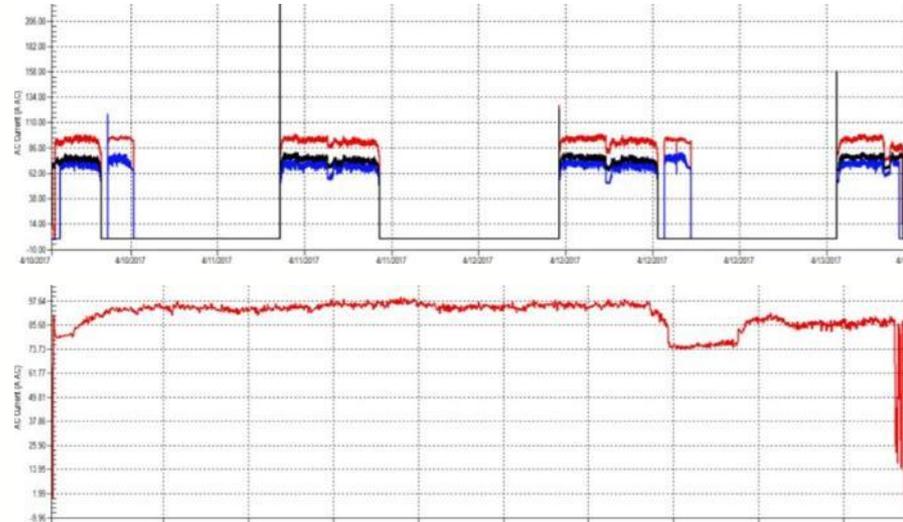


Affordability



Ease

Achieving consistency between three pumps has led to a decrease in the excess current of the pump of the highest load



Harmonics removal - 6



Saving



Affordability

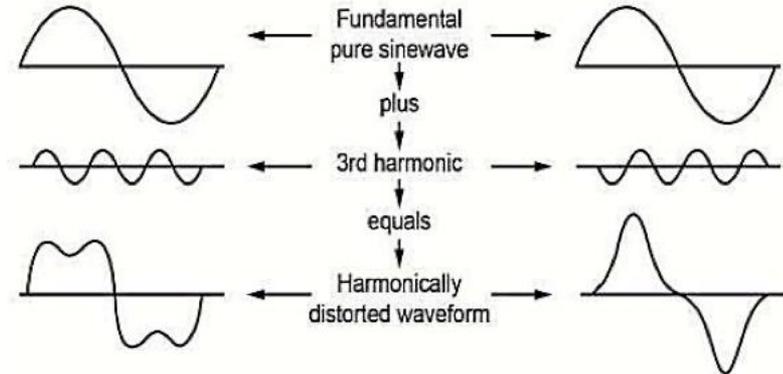
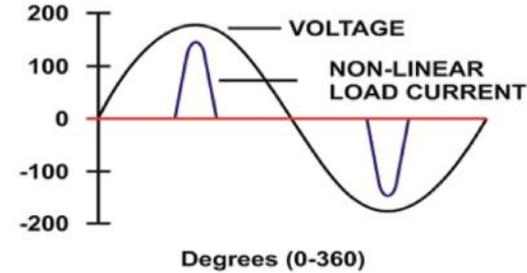


Ease

Harmonics come from

- ✓ Welding machines
- ✓ Electronic equipment, such as inverters
- ✓ Certain loads such as fluorescent lamps
- ✓ Furnaces

Non-linear loads



Pressure reduction - 7



Saving



Affordability



Ease

- ✓ A reduced pressure of 1 bar of compressed air system decreases the electricity consumption by 7%
- ✓ Pressure can be reduced by:
 - Prevention of leak
 - Local boosters
 - Enough air storage



Pressure reduction - 7



Saving



Affordability



Ease

- ✓ Motors are typically re-wound 2-3 times
- ✓ Each re-winding can decrease motor efficiency by 2%
- ✓ Rewinding can preserve efficiency if well done



<https://remsausainc.com>

“Industrial Motors Efficiency Programme (IMEP) Egypt, UNIDO, 2020-2025”

“Manual for INDUSTRIAL MOTOR SYSTEMS ASSESSMENT AND OPTIMIZATION, UNIDO, 2018”

Using VSDs - 8



Saving



Affordability



Ease

- ✓ VSD enable preserving motor efficiency regardless of loading level
- ✓ VSD is recommended when load changes between 25% -1 00%
- ✓ One VSD per group of motors
- ✓ VSDs are sensitive devices



“Manual for INDUSTRIAL MOTOR SYSTEMS ASSESSMENT AND OPTIMIZATION, UNIDO, 2018”

<https://www.automatedelectrics.com.au/blog/magical-motor-power-trick>

Using VSDs - 8



Saving



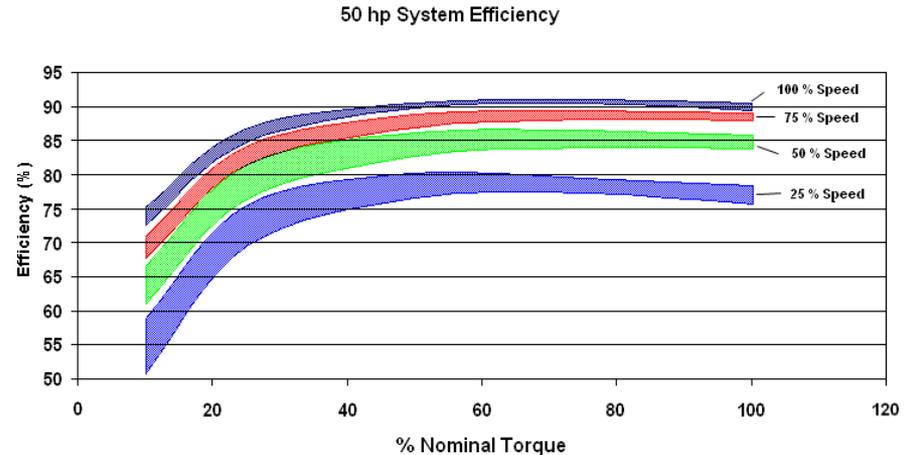
Affordability



Ease

- ✓ If VSDs are used with old motors, failure can take place
- ✓ VSDs shouldn't be installed in case of limiting variation in the load (85% to 100%)

VSD is recommended when the load changes between 25%-100%



Efficient motor sizing - 9



Saving

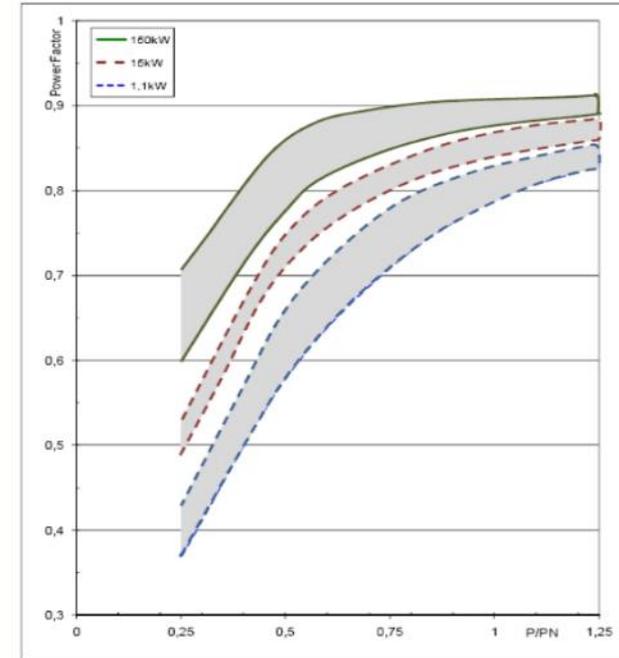


Affordability



Ease

- ✓ Motor oversizing decreases efficiency significantly and leads to higher CAPEX
- ✓ Oversizing is done by designer due to limited precision
- ✓ Oversized motors have no unlike what some could believe



“Manual for INDUSTRIAL MOTOR SYSTEMS ASSESSMENT AND OPTIMIZATION, UNIDO, 2018”

Shift to high efficiency motors - 10



Saving

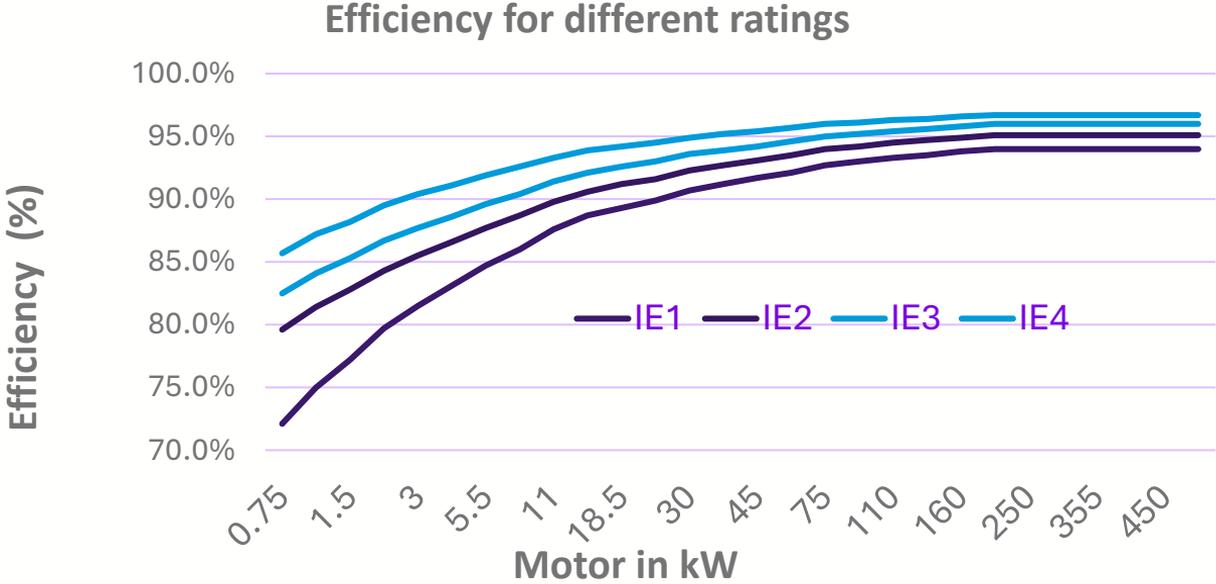


Affordability



Ease

Each IE step up saves about 10%-20% of efficiency in addition to offering less failure rates



“Manual for INDUSTRIAL MOTOR SYSTEMS ASSESSMENT AND OPTIMIZATION, UNIDO, 2018”



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Q&A



Agenda

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Introduction to motor efficiency

Top energy saving measures in motors system

How to calculate savings

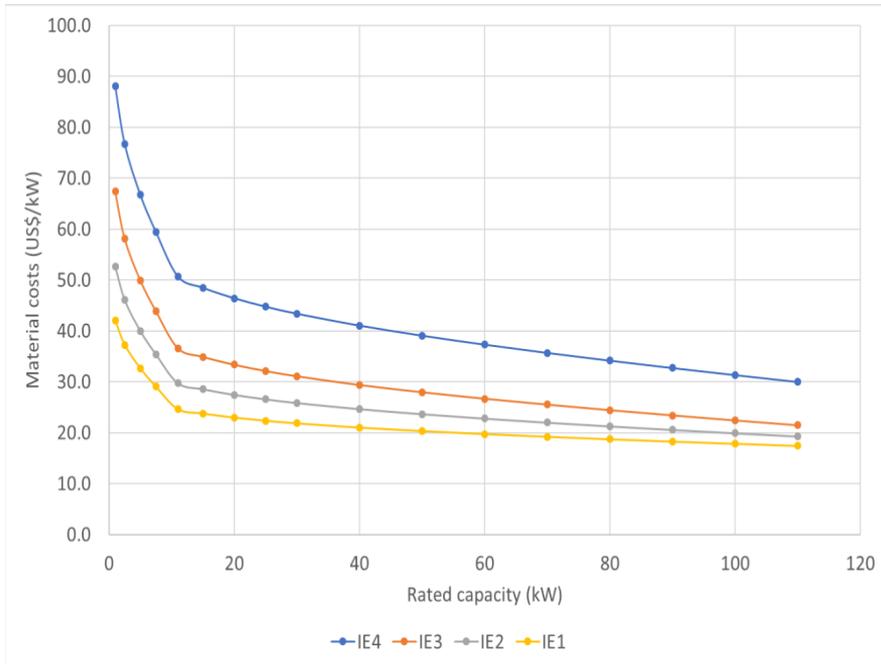
Q&A

How to practically improve motor efficiency in your factory

Evaluation

Closing

How to make a replacement decision – To Repair or to Replace dilemma?



Source: IFC National Energy Efficient Motors Manufacturing Roadmap 2018

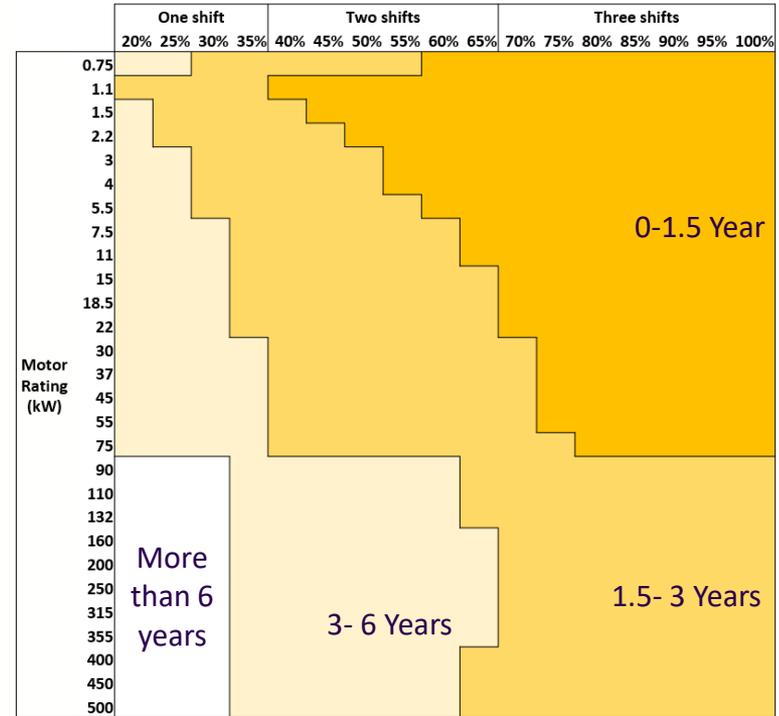
Efficiency for different ratings and IE levels



“Manual for INDUSTRIAL MOTOR SYSTEMS ASSESSMENT AND OPTIMIZATION, UNIDO, 2018”

Results - Replacement Results - Replacement of IE1 motor by IE3 motor

- The longer the annual operating time of the motor, the shorter the payback period of the EE motor (i.e. more feasible)
- Shifting to higher-efficiency motors offers high returns in general
- Priorities include long-duty motors as well as those with higher savings
- Motors that are large and operate for few hours are not a good candidate for investments



Replacing IE1 with IE3

How to make a replacement decision – Repair or Replace dilemma?

If the IE1 motor is defective, should I repair it vs replace it by the IE3 or IE4?

	Repair of IE1	Replacing IE4	Replacing IE3
Cost in USD	2,400	15,000	10,000
Annual Operating hours	8,000	8,000	8,000
loss	25%	5%	7%
Saving Versus Repair	0	4,000	3,400
Payback period		3.2	2.9



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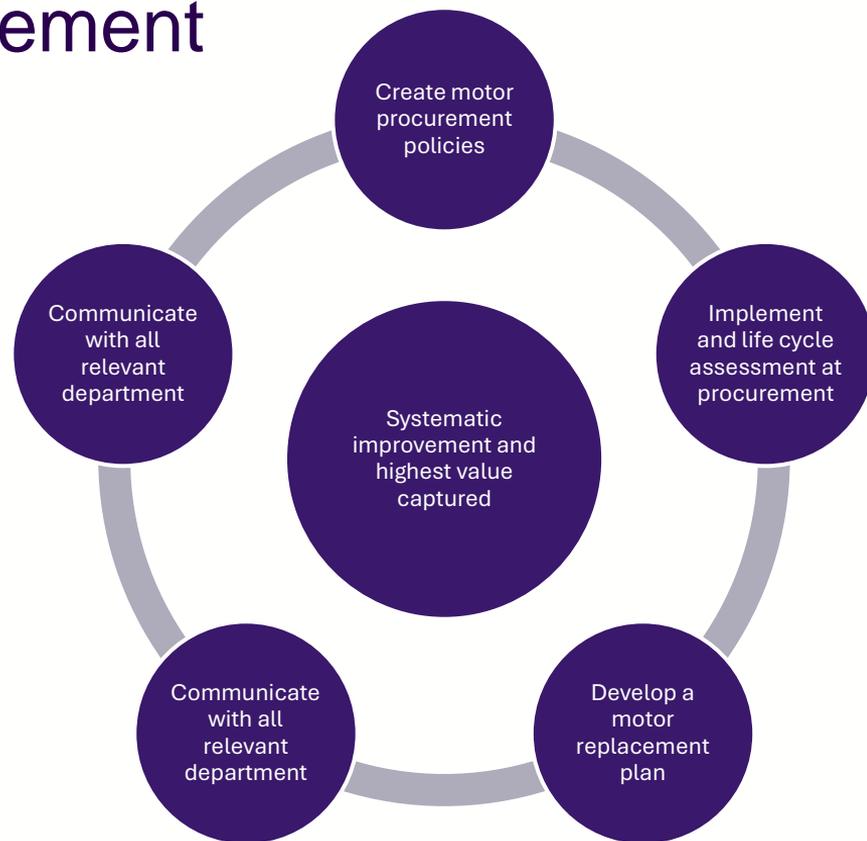
How to practically improve motor efficiency in your factory

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Towards systematic improvement

- It's a process, not a transaction
- When the motor fails, rewinding it is usually replaced with the most available/affordable option
- This rarely leads to the most optimal decision from EE and investment angles





Prioritize replacements

**Higher
returns on
investments**



Older – larger – long duty

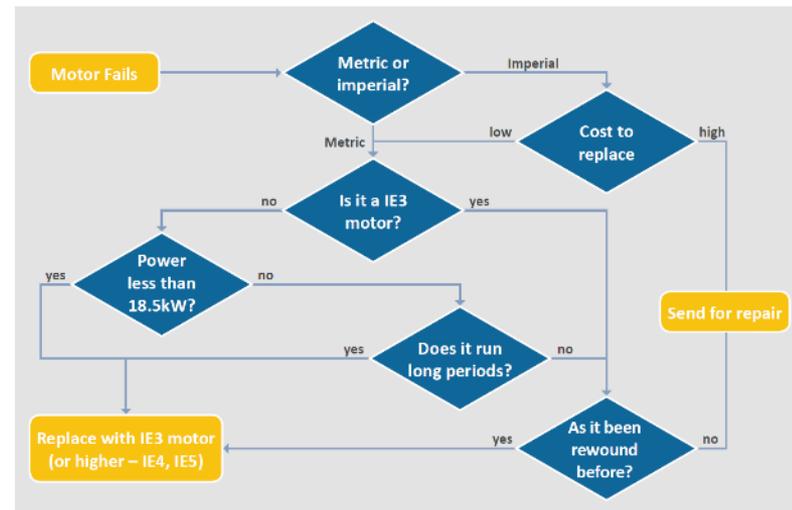
**Lower
returns on
investments**



Newer – smaller – short
duty

Plan investments

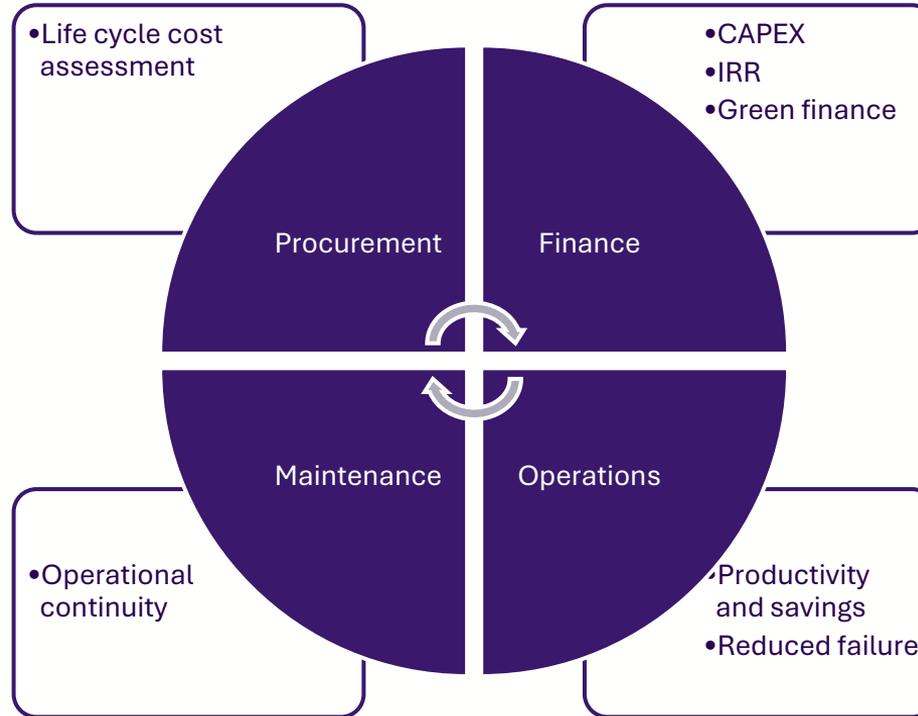
- Based on priorities, make a plan for which motors to replace and when
- The plan needs to speak to all internal stakeholders
- Possible capture green finance opportunities



“Energy Management is not a single project; it is an ongoing programme and way of doing things”



Make the business case





Case study – Kenya

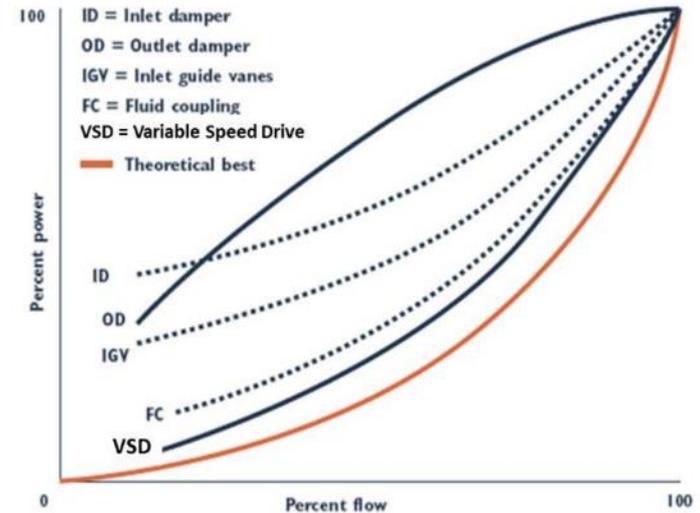
Replacement of three motors low efficiency motors with higher efficiency ones in Schneider Electric Power Plant in Nairobi

	Motor 1	Motor 2	Motor 3
Ratings (kW) (existing)	11	22	37
Efficiency (existing)	86%	87.5%	88.5%
Efficiency (New)	87.5%	87.5%	90.5%
Total CAPEX	327,000 (2,943 USD - @2021)		
Total Savings on energy spending (Kes)	1,335,708 (12,000 USD @2021)		
Payback in months	~ 3 months		

Case study - Egypt

- Optimization of fan systems through a mix of measures in the Egypt SIDPEC plant (part of UNIDO industrial energy efficiency motor – IEE in Egypt)
- Cooling systems operated by 8 x 110 kW fans. The load only requires the full operations at limited times
- Investing in VSDs and control systems led to savings of USD 63,000 per year (at investment cost of USD 6,600)

Relative power consumption of different air flow control methods



Energy Efficient Electric Motors Systems, UNIDO, IMEP, 2020



Case studies - Ecuador

- Novacero works in the recycling of scrap metal with a high reliance on compressors
- Compressor motors (350 HP) were replaced with higher efficiency ones
- CAPEX investments USD 39,299 and annual savings USD 19,085 (17 months payback)



Rotary screw compressor



Case Study - Morocco

Intervention

- Replacement of **legacy/DC motors** with **high-efficiency IE3 & IE4 motors**
- Integration of **VSDs or soft starters** depending on process requirements
- Optimised compressed air systems (leak elimination, removal of inappropriate use, improved control) and upgraded lighting to LED

Results

- **Electricity savings: ~ 2.7 GWh/year**
- **Energy cost savings: ~ USD 350,000/year**
- Savings reported for **energy-efficiency projects as a package, excluding on-site solar PV**

Electricity savings:

The total electrical saving represents 34% of electricity consumption

3.9 GWh per year from solar
2.7 GWh per year via energy efficiency projects



Takeaways

- Motor upgrades deliver **material, recurring OPEX savings**
- Combining **IE3/IE4 motors + VSDs** maximizes returns on variable-load processes



Kenyan Metal Production Facility

Initial cost between 2M and 5M USD, yet:

- Annual financial savings: 1.4M – 3.3M USD
- Payback between 1 and 6 yrs with an average of 2-3 yrs
- Reduces peak demand and kVA exposure, improving load management and resilience

Based on your survey data, here is a summary of your potential savings and payback period following the scenario of replacing all IE0-2 motors with IE3 motors.

Key Survey Inputs

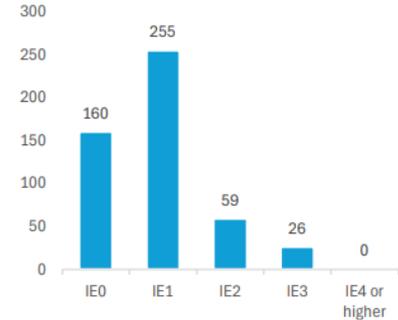
Max electrical load	5800
Number of motors	500
Power factor	0.89

Annual Energy Savings	15814502-31042484 kWh
------------------------------	------------------------------

Annual Financial Savings	1423000-3285000 USD
---------------------------------	----------------------------

Total Investment Estimate	2389250-5153316 USD
----------------------------------	----------------------------

Motor Distribution by Efficiency Type



Estimated Simple Payback By Shifting to IE3

Motor IE Rating	0.75 - 7.5 (kW)	7.5 - 37.5 (kW)	37.5 - 75 (kW)	75 - 375 (kW)	375-500 (kW)
IE0	1.51-1.64 years	1.10-1.21 years	0.83-0.97 years	0.98-1.01 years	1.10-1.10 years
IE1	2.56-2.58 years	1.95-2.09 years	1.57-1.84 years	1.87-1.93 years	2.29-2.29 years
IE2	4.40-5.98 years	3.04-3.42 years	2.60-3.06 years	3.05-3.16 years	4.12-4.12 years

Zambian Aquaculture Facility

Initial cost between 890k and 1.6M USD, yet:

- Annual financial savings: 600k - 1.2M USD
- Payback between 1 and 7 yrs with an average of 2.5-3 yrs
- Motor system optimisation can complement efficiency upgrades by improving load matching and power quality

Based on your survey data, here is a summary of your potential savings and payback period following the scenario of replacing all IE0-2 motors with IE3 motors.

Key Survey Inputs

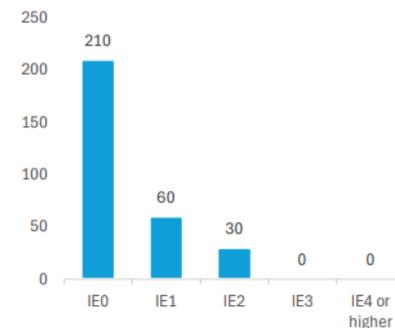
Max electrical load	3200
Number of motors	300
Power factor	0.85

Annual Energy Savings	7665906-15358787 kWh
------------------------------	-----------------------------

Annual Financial Savings	613000-1229000 USD
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Total Investment Estimate	887000-1647415 USD
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Motor Distribution by Efficiency Type



Estimated Simple Payback By Shifting to IE3

Motor IE Rating	0.75 - 7.5 (kW)	7.5 - 37.5 (kW)	37.5 - 75 (kW)	75 - 375 (kW)	375-500 (kW)
IE0	1.69-1.89 years	1.27-1.39 years	0.97-1.14 years	No motors were entered by the factory for IE0 in this output	No motors were entered by the factory for IE0 in this output
IE1	3.04-3.11 years	2.39-2.53 years	1.87-2.16 years	No motors were entered by the factory for IE1 in this output	No motors were entered by the factory for IE1 in this output
IE2	5.19-6.58 years	3.92-4.24 years	3.04-3.52 years	No motors were entered by the factory for IE2 in this output	No motors were entered by the factory for IE2 in this output

Zimbabwean F&B Producer

Initial cost between 300k and 700k USD, yet:

- Annual financial savings: 300k – 82k USD
- Payback between 1 and 3 yrs with an average of 1-2 yrs
- Improved motor efficiency and system optimisation can also reduce reliance on backup generation and exposure to load-shedding

Based on your survey data, here is a summary of your potential savings and payback period following the scenario of replacing all IE0-2 motors with IE3 motors.

Key Survey Inputs

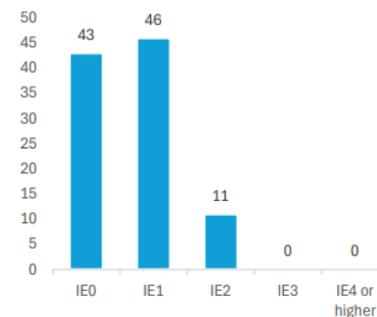
Max electrical load	1000
Number of motors	100
Power factor	0.9

Annual Energy Savings 2372789-6283898 kWh

Annual Financial Savings 308000-817000 USD

Total Investment Estimate 309420-704556 USD

Motor Distribution by Efficiency Type



Estimated Simple Payback By Shifting to IE3

Motor IE Rating	0.75 - 7.5 (kW)	7.5 - 37.5 (kW)	37.5 - 75 (kW)	75 - 375 (kW)	375-500 (kW)
IE0	0.84-0.92 years	0.59-0.65 years	0.63-0.74 years	0.45-0.47 years	No motors were entered by the factory for IE0 in this output
IE1	1.50-1.50 years	1.05-1.13 years	1.19-1.38 years	0.87-0.89 years	No motors were entered by the factory for IE1 in this output
IE2	2.68-3.40 years	1.65-1.85 years	1.96-2.31 years	1.42-1.46 years	No motors were entered by the factory for IE2 in this output



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