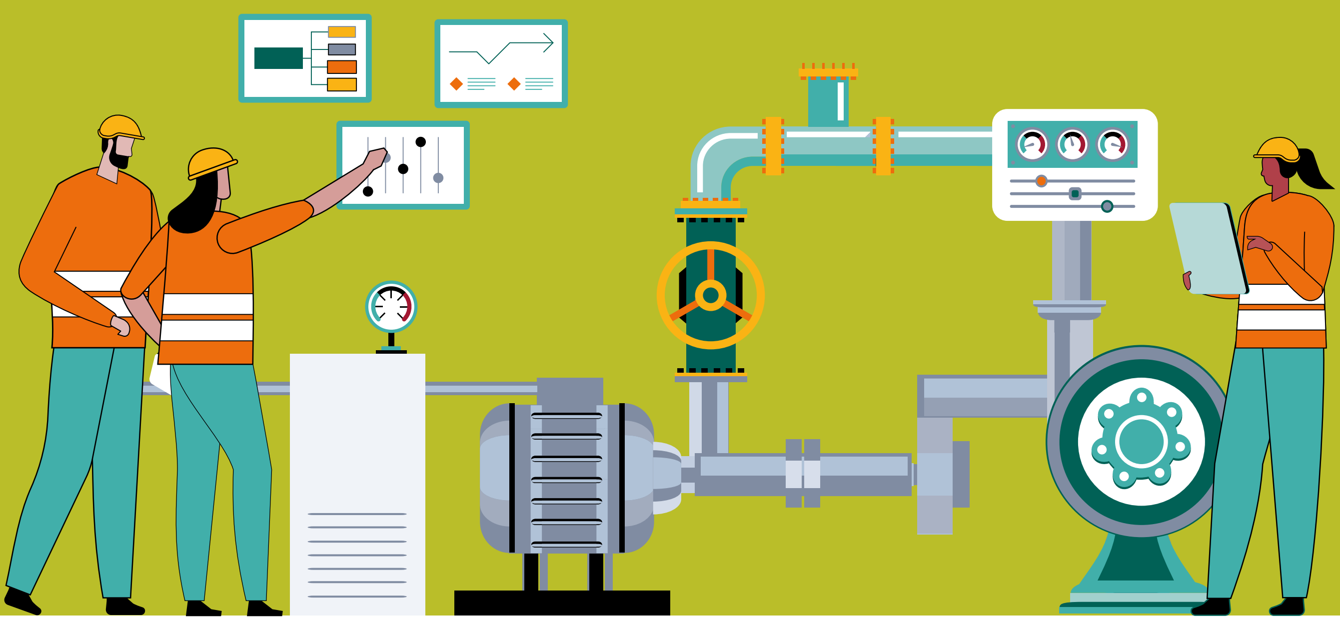
ACCELERATING INDUSTRIES' CLIMATE RESPONSE SRI LANKA

SOLUTIONS FOR MOTOR-DRIVEN SYSTEMS

BROCHURE

Efficiency Solutions for Motor-driven Systems

Energy Efficiency Solutions for Sri Lanka



European Union

Accelerating Industries' Climate Response in Sri Lanka is a project funded by the European Union and implemented by the United Nations Industrial Development Organization with the Ministry of Environment, Ministry of Industry and the Ministry of Power and Energy. The training programme is organized in collaboration with National Cleaner Production Centre, Sri Lanka.

Introduction

Just like an orchestra, an electric motor-driven system is only as efficient as the sum of its parts. One flat note, such as a leaky pipe or a faulty compressor, can ruin the overall performance of the system. That's why it's critical for companies to apply a systemic approach when identifying opportunities for efficiencies. Assessing an entire system can help to uncover inefficiencies beyond the electrical motor, often enabling benefits well beyond reduced energy consumption.

There is no shortage of resources available for industrial managers looking to make their company more energy efficient. In fact, there is so much information it can often be difficult to know where to start or what is worth researching further. This brochure provides an overview for leadership teams on how to achieve more efficient motor-driven systems. Inside you will find insights from UNIDO's global experts as well as external links to recommended manuals and technical guides. You can also find out more about the Accelerating Industries' Climate Response in Sri Lanka project, a 5-year initiative led by the Ministry of Environment, Ministry of Industry and Ministry of Power and Energy and the United Nations Industrial Development Organization (UNIDO) that is helping Sri Lankan industries get the training and technologies they need to become more energy efficient and harness the potential of renewable energy.

Did you know?

Electric motor systems account for about 60 per cent of global industrial electricity consumption and close to 70 per cent of industrial electricity demand.[1]

What are motor-driven systems?

Motors convert electric energy into mechanical motion. They vary vastly in size and can be found everywhere, from micro motors in computer hard drives and small motors in domestic appliances to huge motors used by oil rigs, which can consume the energy equivalent of a small city. Despite differences in size and type, all electric motors work in much the same way: an electric current flows through a wire coil in a magnetic field to create a force.

More than 30 million new electric motors are sold each year for industrial purposes alone. They are responsible for driving both core industrial processes, like presses or rolls, as well as auxiliary systems like compressed air generation, ventilation and water pumping.

Motors need to be connected to a chain of equipment in order to deliver the final motion required. This includes equipment for supplying power, starting the motor and varying its speed, as well as motor-driven equipment such as pumps, fans, conveyors, compressors and specialised production machines.

1 Fleiter & Eichhammer 2012, Energy efficiency in electric motor systems: Technology, saving potentials and policy options for developing countries, UNIDO.

Empowering Sri Lanka's climate efforts through Motor-driven System Optimization

As Sri Lanka aims to reduce its industrial greenhouse gas (GHG) emissions by seven per cent by 2030, its attention is turning to motor-driven systems. Industry is key to the country's economic recovery, with 30 per cent of the workforce employed in the sector, which generated 27 per cent of GDP in 2023. Transitioning to sustainable and energy-saving practices is vital to future-proof industry and reach carbon reduction targets.

As part of UNIDO´s broader Energy Systems Optimization (ESO) programme, the organization is conducting Motor-driven System Optimization (MSO) training. Participants represent multiple key industries in Sri Lanka, from textile and rubber manufacturing to food production and packaging. All sectors that typically use substantial amounts of energy in their production processes. The course, led by Energy Management and Motor-Driven Systems Expert Siraj Williams and Motor-Driven Systems Expert Prof. Anibal T. De Almeida, encourages participants to look beyond the individual motor and examine the system as a whole. Participants learn how to operate motor systems in a more energy-efficient way, through both classroom sessions and digital simulations.

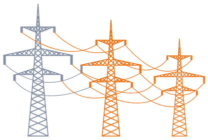
> **"The MSO training showed me opportunities I could use to save energy by optimizing the motor systems in these machines, as well as reducing maximum demand as a large power consumer. We have made significant progress in reducing the kilo-volt-ampere (kVA) consumption in our plant from 4000 kVA consumption per month to 3600 kVA by applying power factor correction practices of 0.98 or higher. This translates to substantial savings in electricity costs for the company."**
>
> **Supun Sandaruwan,** Senior Electrical Engineer at TeeJay Lanka PLC.

Participants who successfully complete the programme return to their organizations as UNIDO Certified MSO experts, ready to harness the significant untapped potential for energy efficiency in electric motor-driven systems at their facilities. The MSO training lays the foundation for more advanced programmes including Pump System Optimization (PSO) and Compressed-air System Optimization (CASO).

> **"In our plant, where we extrude polythene film, we encountered a bottleneck when working with recycled materials. There were blockages at the filtering stage which increased pressure and caused temperature spikes. Drawing on my MSO training knowledge, I assessed that the machine was operating at only 60 per cent efficiency. By replacing the nets and filters, increasing the filtering area and adjusting the barrel pressure and screw speed accordingly, we anticipate reaching an efficiency level of around 85 per cent."**
>
> **W.K.A.A. Chaturanga,** Production Manager at Finnpack Industries.

> **"Using the tools and knowledge acquired through the training, I was able to conduct a thorough assessment of the system and determine that integrating a more compatible capacity inverter would not only significantly reduce energy consumption but also extend the lifespan of the motor and ball mill, while minimizing maintenance requirements."**
>
> **S.M.P.S Samaraweera,** Production Engineer at Noritake Lanka Porcelain.

Components of a motor-driven system



Power supply

The primary function of a power supply is to transmit an electric current from a source such as an electrical outlet, a battery, generator, alternator or a renewable source such as a solar power converter, into a motor system.

Power equipment

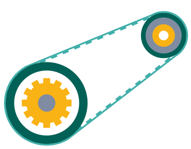
Transformers, switchgears and cables are electric apparatuses that transfer electrical energy from a source like a generator to an end use application such as an electric motor. The power equipment is designed to maximise the energy transfer in a safe and effective way.

Controls

When an electric induction motor is directly connected to the electrical supply, it will operate at a fixed speed depending on the nature of the load. A soft starter may be used to control the high start up currents. When a variable speed is desired, an electronic control unit called a variable speed drive may be used to control the motor speed and torque, as well as to soft start the motors.

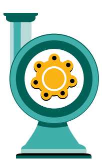
Motor

An electric motor is the device which converts electrical energy into mechanical energy to enable motion.



Mechanical transmission

A transmission is a device in a motor system such as a direct coupling, a gearbox, a belt, a pulley or a chain and sprocket arrangement, which can be used to vary the final speed and torque of the mechanical load application such as a fan or pump. Electromagnetic clutches and disc brakes are also other examples which aid in rapid stopping of the motorised power.



Driven equipment

Driven equipment simply refers to the machinery which is being powered by the electric motor to produce the final motion. This could be an air or water pump, a fan, a gas compressor, a conveyor to move materials, or some type of production machine.

Mechanical controls & process components

The remainder of the process can include components such as pipes, throttles and valves which transport liquids and gases.

Optimized motor-driven systems

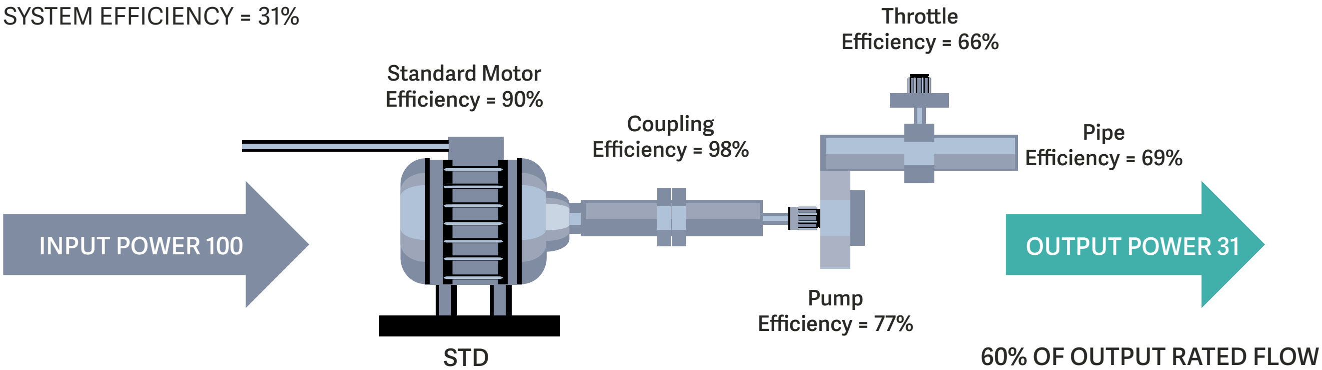
What is meant by 'system' optimization?

An efficient electric motor and the use of variable speed drives is of little value if pipes are blocked in a pump system, or if there are leaks in a compressed air system. Similarly, if a motor is idly running and not providing a mechanical end use benefit, then energy will be wasted, regardless of the equipment's efficiency rating. System optimization approaches address the entire motor system, from the power supply to the mechanical controls and everything in between. A motor is considered just one of many opportunities for optimization.

Comparison of a typical pump system versus an optimized system

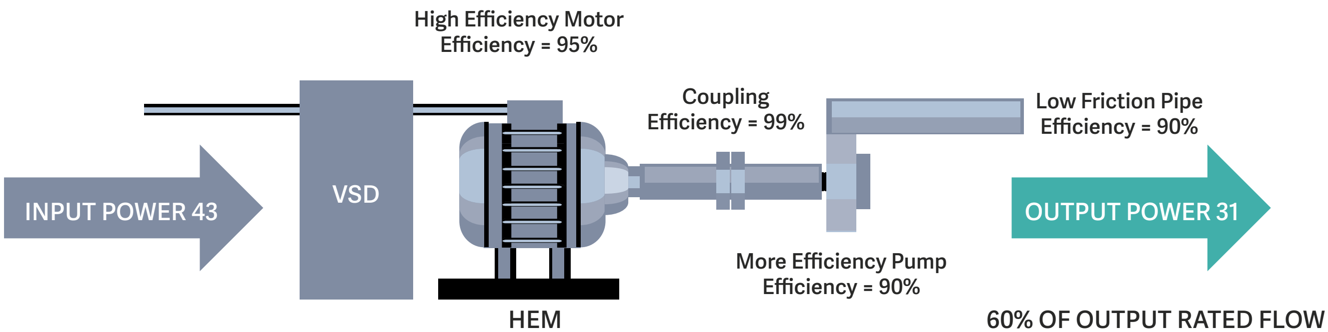
CONVENTIONAL PUMPING SYSTEM

SYSTEM EFFICIENCY = 31%



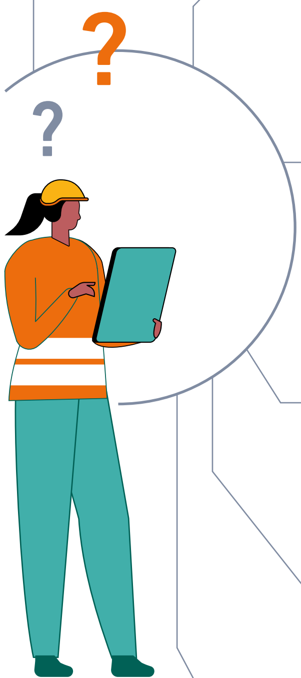
ENERGY EFFICIENT PUMPING SYSTEM

SYSTEM EFFICIENCY = 72%



Source: de Almeida, A & Ferreira, F & Both, D 2004 "Technical and Economic Considerations to Improve the Penetration of Variable-Speed Drives for Electric Motor Systems," IEEE Industrial and Commercial Power Systems Technical Conf. (ICPS'04), Conf. Rec., pp. 136-144.

Questions to ask when assessing the efficiency of a motor system



1. Is all of this water, air or energy actually needed to achieve the desired outcome?

2. Is each component in the system optimized to provide the best overall system efficiency? Are all the components necessary? Is there newer technology which can be applied to improve the performance of key components as well as the overall system performance?

3. Are there possibilities for energy recovery in the motor system, such as using gravity to provide energy storage (e.g. as in cranes or lifts) or kinetic energy (e.g. regenerative braking in vehicles)?

4. What are the operational set points for the system being assessed? How were they determined? Are they valid for all operating conditions?

5. Is there a difference in the understanding of how much energy is needed between the engineering team and the plant management team? How can everyone get on the same page?

6. Is there a single set of appropriate metrics used across all departments to monitor the energy performance of critical and large motor systems?

Strive for high performance

The efficiency of a motor-driven system depends upon several integrated factors

Energy requirements of end-use application

It is important to understand, and where possible, quantify the actual end-use power and energy demand of the application. In many cases the end-use requirement is over specified to provide for a "just in case" scenario.

Efficiency of the end-use device

For each motor, consider the efficiency of the equipment and mechanical load that it is driving such as the fan or pump. Are they correct for the actual end use application? Do they need to be repaired or replaced?

Motor quality

Efficient motors are typically constructed with superior materials. This includes larger magnetic circuits with high-grade magnetic steel and thinner laminations, a larger copper or aluminium cross-section in the stator and rotor windings, tighter tolerances as well as better quality control and optimized design.

Motor size

Getting the motor size right is one of the many ways to maximise efficiency. Motors should run primarily in the 65 per cent to 100 per cent load range. Consider replacing motors which are consistently running at less than 40 per cent load with smaller sized motors.

Motor controls

When used correctly, electronic motor controls such as variable speed drives can save significant amounts of energy, reduce wear on the mechanical system, and improve performance.

Power quality

Optimal energy performance is achieved when fed by a pure sinusoidal wave at 50 or 60 hertz depending on location.

Distribution network

Ensuring that transformers are operating at the correct voltages is an important cost effective way to minimise energy losses in the distribution network.

Mechanical transmission

Adequate transmission design, use of high efficiency equipment, appropriate lubrication as well as maintenance and manufacturing techniques can help to prevent significant power losses when mechanical power is transferred from the motor to the final end-use.

Maintenance practices

Regular maintenance such as inspection, cleaning, lubrication and tool sharpening is essential to maintain peak performance of mechanical parts and to extend their operating lifetime.

Load management

Load management allows utilities to reduce demand for electricity during peak usage times, which can help to reduce costs by eliminating the need for peaking power plants.

ADDITIONAL RESOURCES

READ

→ UNIDO 2012, **'Energy efficiency in electric motor systems: Technology, saving potentials and policy options for developing countries'.**

→ A. De Almeida et al 2019, **'New technology trends and policy needs in energy efficient motor systems - A major opportunity for energy and carbon savings'.**

WATCH

→ Topmotors Webinar 2020, **'New global motor standards move the market'.**

The benefits

There is a huge, untapped potential for energy efficiency in electric motor-driven systems. Around 25 per cent of motor-driven electricity consumption could be saved with low-cost investments. This would reduce total global electricity demand by about 10 per cent.[2]

In UNIDO's experience, on average, motor-system optimization can reduce an individual plant's energy consumption by up to 30 per cent. Most motor optimization investments show payback times within three years.

Other organizational **benefits include:**

- Cost savings related to reduced energy consumption
- Lower total life cycle cost of motor systems
- Reduction in carbon emissions
- Improved final product quality
- Improved operational reliability and control
- Peak power reduction
- Ability to increase production without requiring additional, and possibly constrained, energy supply
- Lower acoustic noise and improvement of the process control
- Less wear maintenance needs of the mechanical components
- Monetized specific savings goals
- Lower maintenance
- Improved production processes
- Improved environmental performance
- Improved workplace conditions
- Enhanced corporate reputation

Furthermore, the optimization of motor-systems within industrial organizations provides multiple benefits that extend far beyond the more direct energy and corresponding system improvements. With existing technologies and practices, efficient industrial electric motor-driven systems have the potential to reduce global electricity consumption by up to 4.8 exajoules. This would dramatically reduce emissions worldwide and save industry between USD $72 – 108 billion annually.[3]

Electric motors and the systems they drive are the single largest electrical power consumers—more than twice as much as lighting, the next largest energy-consuming product.[4]

"We operate seven extruders, each powered by 75 hp motors, to produce cereal powder. Following the MSO training, I identified several opportunities to minimize energy wastage in our machines: integrating soft-starters, transitioning to direct coupling for transmission instead of belts, and introducing automation to reduce stoppages. By monitoring motor amperage, lubrication levels can automatically be adjusted, which decreases energy usage during high-amperage operation. The extruders account for 60 to 75 per cent of our total energy costs. I believe that with these measures in place, we can achieve a 20 per cent reduction in the energy consumption of these machines."

Chaminda Hulangamuwa, CBL Plenty Foods (Pvt) Limited.

2 IEA 2011, **'Energy Efficiency Policy Opportunities for Electric Motor-Driven Systems'.**

3 **IEE, Egypt 2016.**

4 CLASP, **'Motors'.**

UNIDO's 'systems' approach

Not all of the electric energy that goes into a motor is converted to usable mechanical energy. Some of this energy is lost as heat during the conversion process, in the magnetic materials or through friction from inefficient motor bearings and via lubrication. Such losses occur at each step in the electric motor system, which compound along the way and can result in significant overall inefficiencies. As a result the energy savings opportunities from system optimization are far greater than from individual components. **Typically, component approaches can result in energy savings of 3 to 5 per cent. Whereas a systems approach can result in energy savings of between from 10 to 50 per cent**. For this reason, UNIDO has long championed a 'motor-systems' approach to achieving efficiency rather than focusing on the maintenance of individual components.

ADDITIONAL RESOURCES

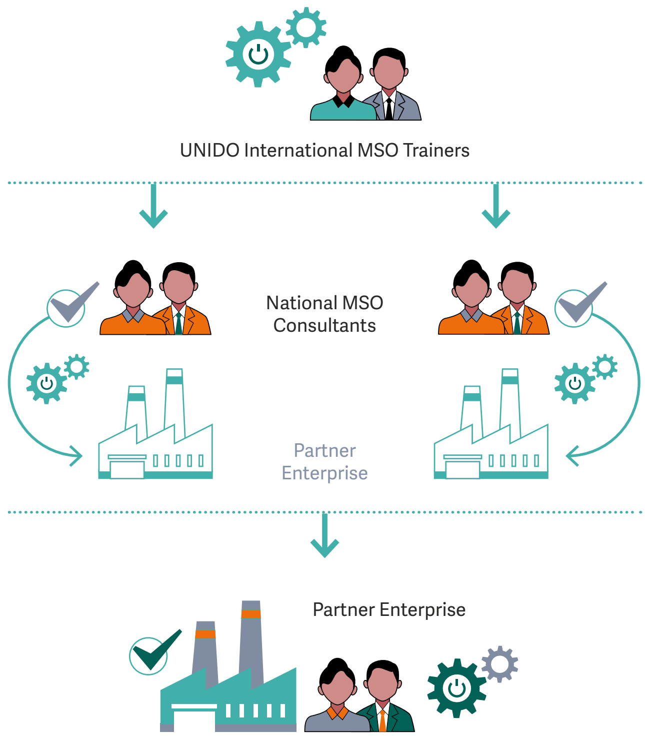
- UNIDO 2018, **Manual for industrial motor systems assessment and optimization.**
- UNIDO 2016, **Energy efficient electric motors systems.**
- UNIDO 2016, **Manual for industrial pump systems assessment and optimization.**
- EMSA 2018, **Energy audit guide for motor-driven systems. Recommended steps and tools.**

UNIDO case studies
Myanmar
Proven Technologies - optimization of compressed air system

Egypt
Evergrow Company - installation of variable speed drives

A hands-on experience

UNIDO's Motor Systems Optimization (MSO) Capacity Building and Implementation Programme brings international experts together with national trainees, vendors and host companies, creating a ripple effect of knowledge sharing, simultaneously fostering demand and supply in national markets for energy efficiency services. The MSO programme takes participants beyond the classroom into industry where they implement real-life projects in partner enterprises.



Broken into two user streams, which include advanced training to qualify MSO experts as trainers and assessors, this unique programme is designed for a variety of motor-driven systems.

The UNIDO Motor-driven Systems Optimization (MSO) Training Programme

A systemic approach for efficiency

Four training programmes for the optimization of motor-driven systems:

- Fans
- Compressed Air
- Pumps
- Motors

PREPARATION — 2-3 MONTHS

USER TRAINING — 2 DAYS

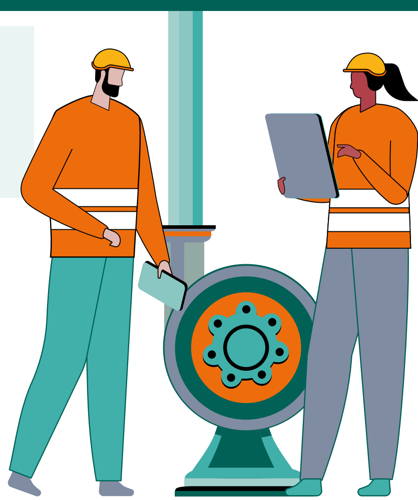
Targeted to facility engineers, operators and maintenance staff of enterprises, as well as equipment vendors and service providers.

EXPERT TRAINING

- 3-4 WEEKS — Reportings & presentations
- 3-6 MONTHS — Individual industry assessments
- 5-6 DAYS — Theory & demonstration of industry assessment

PROGRAMME COMPLETION

- 1 DAY — Revision & lessons learned
- 2-3 WEEKS — Final assessment
- 1 DAY — Graduation ceremony



COMMUNICATION & DISSEMINATION

OUR TARGETS

Our goal is to help cut greenhouse gas emissions in Sri Lanka's industrial sector by 7 per cent by 2030. We will do this by supporting Sri Lankan companies to improve the efficiency of industrial processes and move to renewable energy.

400
LOW COST/NO COST ENERGY EFFICIENCY SOLUTIONS IMPLEMENTED BY INDUSTRIES

200
ENERGY EFFICIENCY PROFESSIONALS TRAINED TO IMPLEMENT ENERGY EFFICIENCY MEASURES

100 INDUSTRIES IMPLEMENT ISO 50001 EnMS AND ESO MEASURES
50001 STANDARD

100
SUPPLIERS TRAINED TO DESIGN AND INSTALL RENEWABLE ENERGY SYSTEMS

80
BANKABLE INVESTMENTS PROPOSALS GENERATED FOR FINANCING

50
GOVERNMENT OFFICIALS TRAINED IN GHG EMISSIONS ACCOUNTING, VERIFICATION AND REPORTING

10
HIGH IMPACT LOW-CARBON TECHNOLOGY DEMONSTRATION PROJECTS IMPLEMENTED

CASE STUDIES PUBLISHED ON IMPLEMENTATION OF INDUSTRY DECARBONIZATION SOLUTIONS
70 CASE STUDIES

5
NATIONAL INSTITUTIONS INTEGRATE EnMS AND ESO IN THEIR TRAINING PROGRAMMES

Your motor-driven systems questions answered

UNIDO has steadily grown its cohort of international and national motor-system optimization experts over the past decade. With collective experience in all of the world's major industrial countries and regions our team of specialized consultants have a long track record of leading organizational teams to achieve impressive energy savings. In this kit you will find a video featuring two of our experts answering common questions about motor system optimization.

Anibal De Almeida
Motor-driven Systems Expert

Over the years, Anibal has led numerous international projects and initiatives focusing on automation and energy efficient technologies with particular emphasis in advanced electric motors and drives. He is a Full Professor at the University of Coimbra, Portugal, where he is also the Director of the Institute for Systems and Robotics (UC). He holds a PhD in Electrical Power Systems from Imperial College, University of London.

Siraj Williams
Energy Management and Motor-driven Systems Expert

As a registered professional engineer, Siraj has been involved in industries related to electrical energy infrastructure and industrial energy consumption for over 25 years. In 2012 Siraj attended a UNIDO course on pump system optimization. Today Siraj is a UNIDO qualified expert and trainer in Resource Efficiency and Cleaner Production (RECP), Energy Management Systems (EnMS), Energy Performance Management and Indicators (EnPI), and also a systems expert in electric motors, compressed air and pump systems.

ACCELERATING INDUSTRIES' **CLIMATE RESPONSE** SRI LANKA

www.industriesclimateresponse.com

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