Digitizing Industrial Motor Systems for Energy Efficiency
Efficient Electric Motor Systems

Overview of motor system energy efficiency improvement

SAARC Energy Center
(online)

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Global electricity end-use

ELECTRIC MOTOR DRIVEN SYSTEMS (53 %)

Buildings:
- Appliances, lighting, water heating, space heating, cooking

Industry:
- Pumps, fans, compressors-air/cooling, transport, etc.
- Process heat, electro-chemical, process cooling, lighting, etc.

Transport

Agriculture

Global end-use electricity: IEA WEO 2016

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Electric Motor Systems

Electric motors drive:
- pumps
- fans
- air- and cooling-compressors
- transport systems
- handling & process systems
- others

- 53% of global electricity use
- Industry: share 60-70%

Source: IEA World Energy Outlook 2016
10'800 TWh/a (2016)
System standards - energy efficiency

Source: IEC 60034-31
Motor Efficiency

IE-Code for efficiency of electric motors: 4-pole, 50 Hz

- IE4 - Super Premium Efficiency 50 Hz
- IE3 - Premium Efficiency 50 Hz
- IE2 - High Efficiency 50 Hz
- IE1 - Standard Efficiency 50 Hz

Available at [www.iec.ch](http://www.iec.ch)
## Minimum Requirements for Motors

<table>
<thead>
<tr>
<th>Efficiency Levels</th>
<th>Efficiency Classes</th>
<th>Testing Standard</th>
<th>Performance Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>3-phase induction motors (Low Voltage &lt; 1000 V)</td>
<td>IEC 60034-30-1, 2014</td>
<td>incl. stray load losses</td>
<td>Mandatory MEPS III</td>
</tr>
<tr>
<td><strong>Super Premium Efficiency</strong></td>
<td>IE4</td>
<td>Preferred Method</td>
<td>National Policy Requirement</td>
</tr>
<tr>
<td><strong>Premium Efficiency</strong></td>
<td>IE3</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>High Efficiency</strong></td>
<td>IE2</td>
<td>Summation of losses with load test: Additional losses $P_{UL}$ determined from residual loss</td>
<td></td>
</tr>
<tr>
<td><strong>Standard Efficiency</strong></td>
<td>IE1</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Region</th>
<th>Power Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Canada</td>
<td>0.75 - 375 kW</td>
</tr>
<tr>
<td>Mexico</td>
<td>0.75 - 375 kW</td>
</tr>
<tr>
<td>USA</td>
<td>0.75 - 375 kW</td>
</tr>
<tr>
<td>USA, Canada</td>
<td>0.18 - 2.2 kW</td>
</tr>
<tr>
<td>South Korea</td>
<td>0.75 - 375 kW</td>
</tr>
<tr>
<td>EU 27, UK</td>
<td>0.75 - 1000 kW</td>
</tr>
<tr>
<td>Switzerland</td>
<td>0.75 - 375 kW</td>
</tr>
<tr>
<td>Japan</td>
<td>0.75 - 375 kW</td>
</tr>
<tr>
<td>China</td>
<td>0.12 - 1000 kW</td>
</tr>
<tr>
<td>Israel</td>
<td>7.5 - 375 kW</td>
</tr>
<tr>
<td>Singapore</td>
<td>0.75 - 375 kW</td>
</tr>
<tr>
<td>Taiwan</td>
<td>0.75 - 375 kW</td>
</tr>
<tr>
<td>Brazil</td>
<td>0.12 - 370 kW</td>
</tr>
<tr>
<td>Ukraine</td>
<td>0.75 - 375 kW</td>
</tr>
<tr>
<td>Egypt</td>
<td>0.75 - 375 kW</td>
</tr>
<tr>
<td>Turkey</td>
<td>0.75 - 375 kW</td>
</tr>
<tr>
<td>Saudi Arabia</td>
<td>0.75 - 375 kW</td>
</tr>
<tr>
<td>Australia</td>
<td>0.73 - 195 kW</td>
</tr>
<tr>
<td>EU 27, UK</td>
<td>0.12 - 0.75 kW</td>
</tr>
<tr>
<td>Chile</td>
<td>0.75 - 75 kW</td>
</tr>
<tr>
<td>China</td>
<td>0.75 - 375 kW</td>
</tr>
<tr>
<td>Peru</td>
<td>0.75 - 375 kW</td>
</tr>
<tr>
<td>Colombia</td>
<td>7.5 - 375 kW</td>
</tr>
<tr>
<td>New Zealand</td>
<td>0.73 - 195 kW</td>
</tr>
<tr>
<td>Israel</td>
<td>0.75 - 375 kW</td>
</tr>
<tr>
<td>EAEU</td>
<td>0.75 - 375 kW</td>
</tr>
<tr>
<td>India</td>
<td>0.12 - 1000 kW</td>
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<tr>
<td>Ecuador</td>
<td>0.748 to 373 kW</td>
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<tr>
<td>Peru</td>
<td>0.75 - 375 kW</td>
</tr>
<tr>
<td>Kenya</td>
<td>0.75 - 375 kW</td>
</tr>
<tr>
<td>Argentina</td>
<td>0.75 - 30 kW</td>
</tr>
</tbody>
</table>

**Source:** 4E EMSA 2021
Efficiency for industrial motor systems:

1. Design for necessary demand: pressure and flow, capacity, temperature, etc.

2. Downsize all components to actual demand.

3. Use motor only when necessary.

4. Load control is imperative for changing load applications.

5. Go to direct-drive wherever possible.

6. Use digital monitoring and remote control.
Fan with V-Belt, big motor, no load control
Zhengzhou Kaishan
JN Series Energy-Saving Two-Stage Screw Air Compressor

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SAARC
BBC IE0, before 1988 (fresh paint)
Danfoss VFC with screw compressor
Digital motor systems

- Condition monitoring
- Remote control (www)
- Load control
- Digital Twin

system failure
performance check
energy savings
system optimisation

www.ptc.com
www.job-wizards.com

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Digital sensors for motor monitoring

Sensors record temperature, vibrations, operating time, maybe also speed, torque
THE #1 CASE
the outset

• any 0.1….1000 kW nominal output machine
• could be a pump, a fan, a compressor, anything that rotates

• the machine at the outset:
   oversized, with fixed speed, with gear and V-belt, current market components

• the system improved:
   downsized, with adjustable speed, direct drive, efficient components, remote control
The efficient motor systems means:

1. Supply mets demand: no more oversizing
2. Time of use: run only when needed (night, weekend)
3. No standby losses
4. Motor connects to pump/fan directly: no gear and belt necessary ➤ direct drive
5. Load control is necessary: variable frequency drive
6. Use high efficient components:
   • motors: IE4
   • VFD: IE2 or IE3 (variable frequency drive)
   • BAT for pumps and fans (best available technology)
7. Remote control is next
# Repaired vs. New Motor

## Repaired motor (after 50'000 h)
- Motor dismantling, rewind, assembly: takes days or weeks
- Efficiency decreased with rewind
- Repair cost below 10 kW is higher
- Same size,
- Same type motor: fixed speed
- Runs hot
- More greasing
- More maintenance
- Risk of failure

► A repaired motor is never a new motor

## New motor (after 10 years)
- Plan ahead for delivery of new motor: installation takes days
- Efficiency increased with IE3 / IE4
- Cost of new motor above 10 kW is cheaper
- Resizing/downsizing is possible,
- Better motor type possible: poles, heat
- Runs cooler
- Less greasing necessary
- Less maintenance, no failure
- Use of variable frequency possible

► Recycling of old motor is easy
Thank you, questions?

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ISO TC 115 Pumps and ISO 117 Fans


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4E EMSA: Electric Motor Systems Annex

www.motorsystems.org
www.topmotors.ch