Optimización de Sistemas de Fuerza Motriz
Múltiples beneficios del Ahorro Energético

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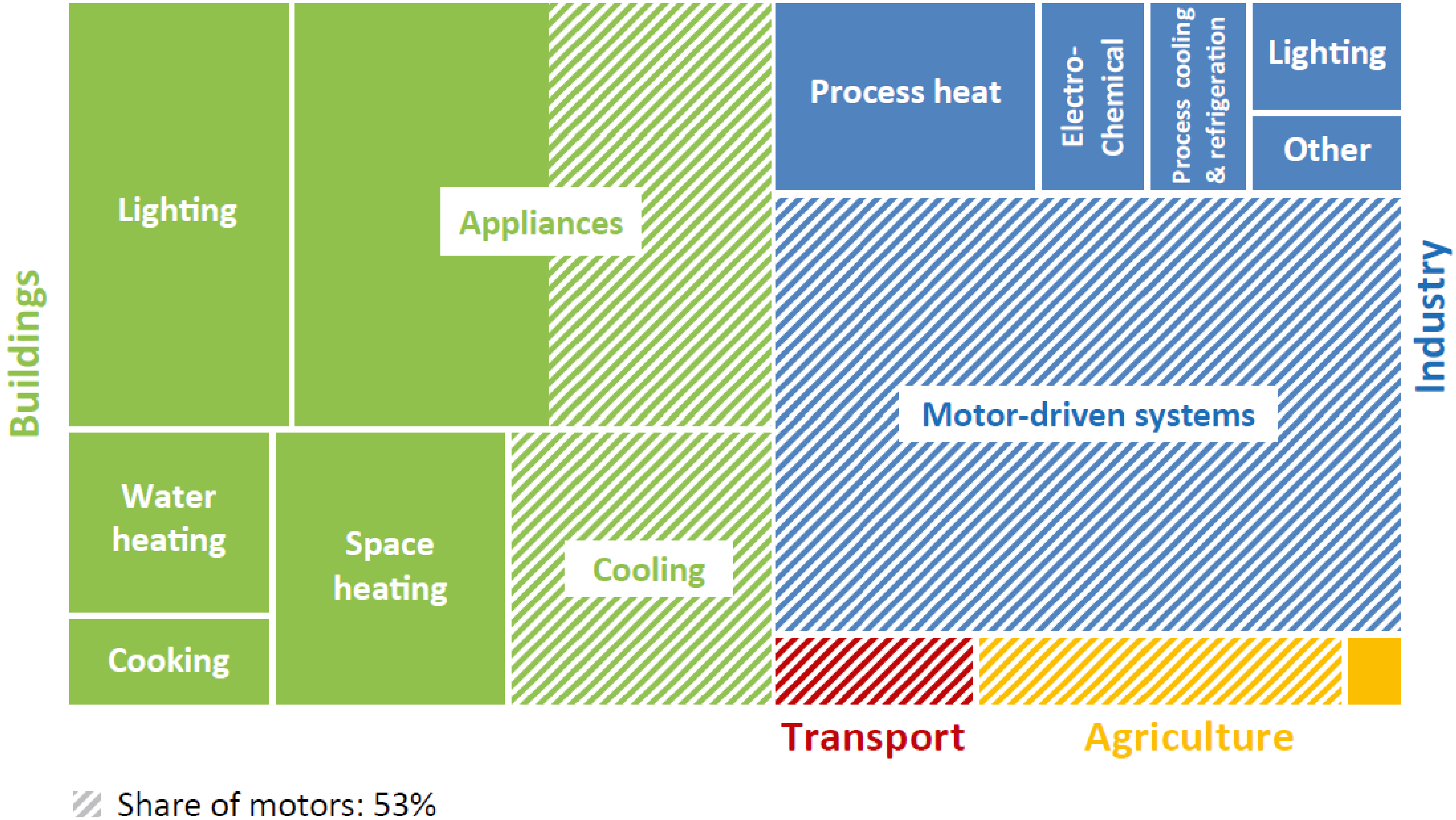
EEI Eficiencia Energética Industrial en Colombia

gef GLOBAL ENVIRONMENT FACILITY
INVESTING IN OUR PLANET

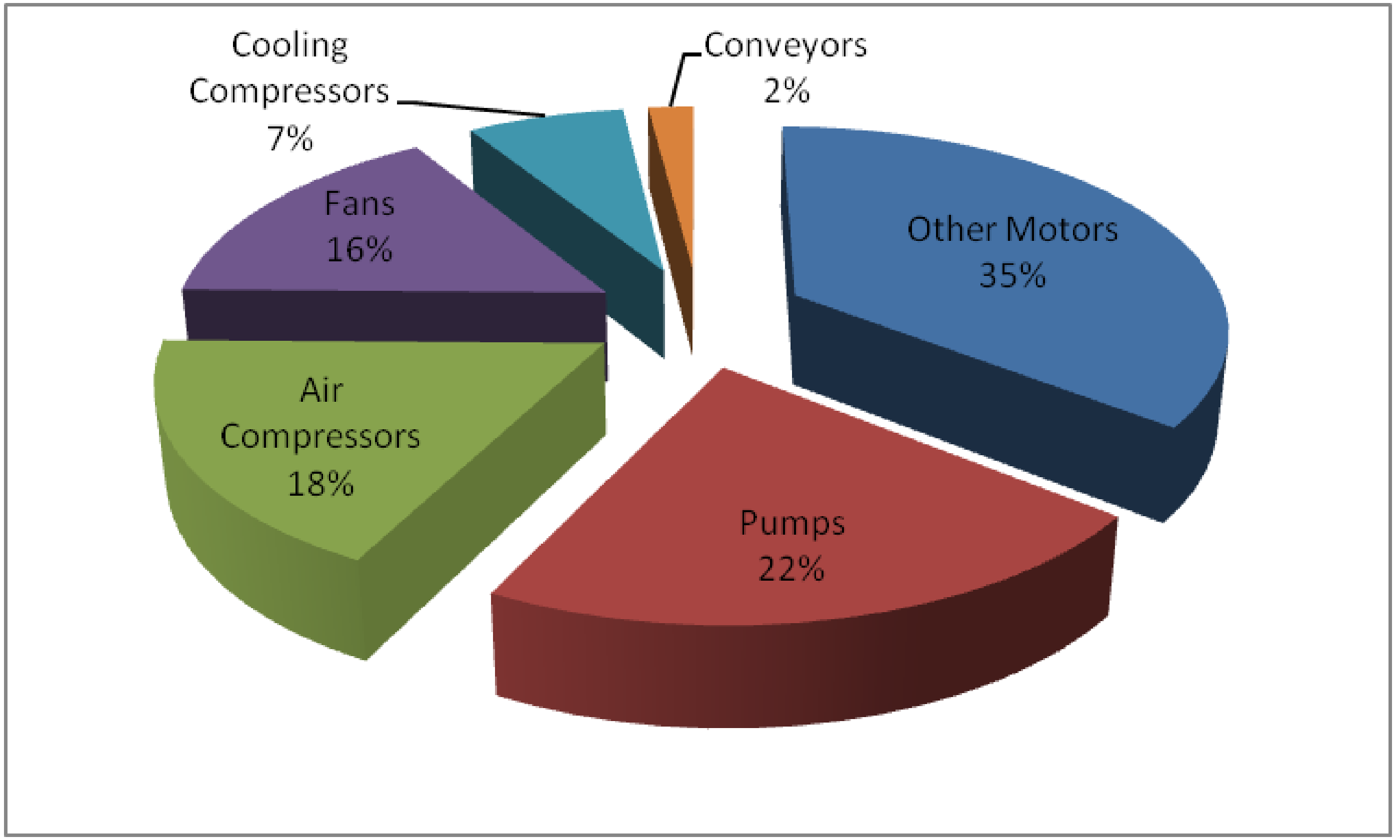
upme
Unidad de Planeacion Minero Energetica

Global total final electricity consumption by end-uses, 2014



Source:IEA World Energy Outlook

Industrial motor systems energy use



Disaggregation of motor electricity consumption by end-use, in the EU Industrial sector

Motor Systems Energy Use

The efficiency of a motor system depends on several factors, including:

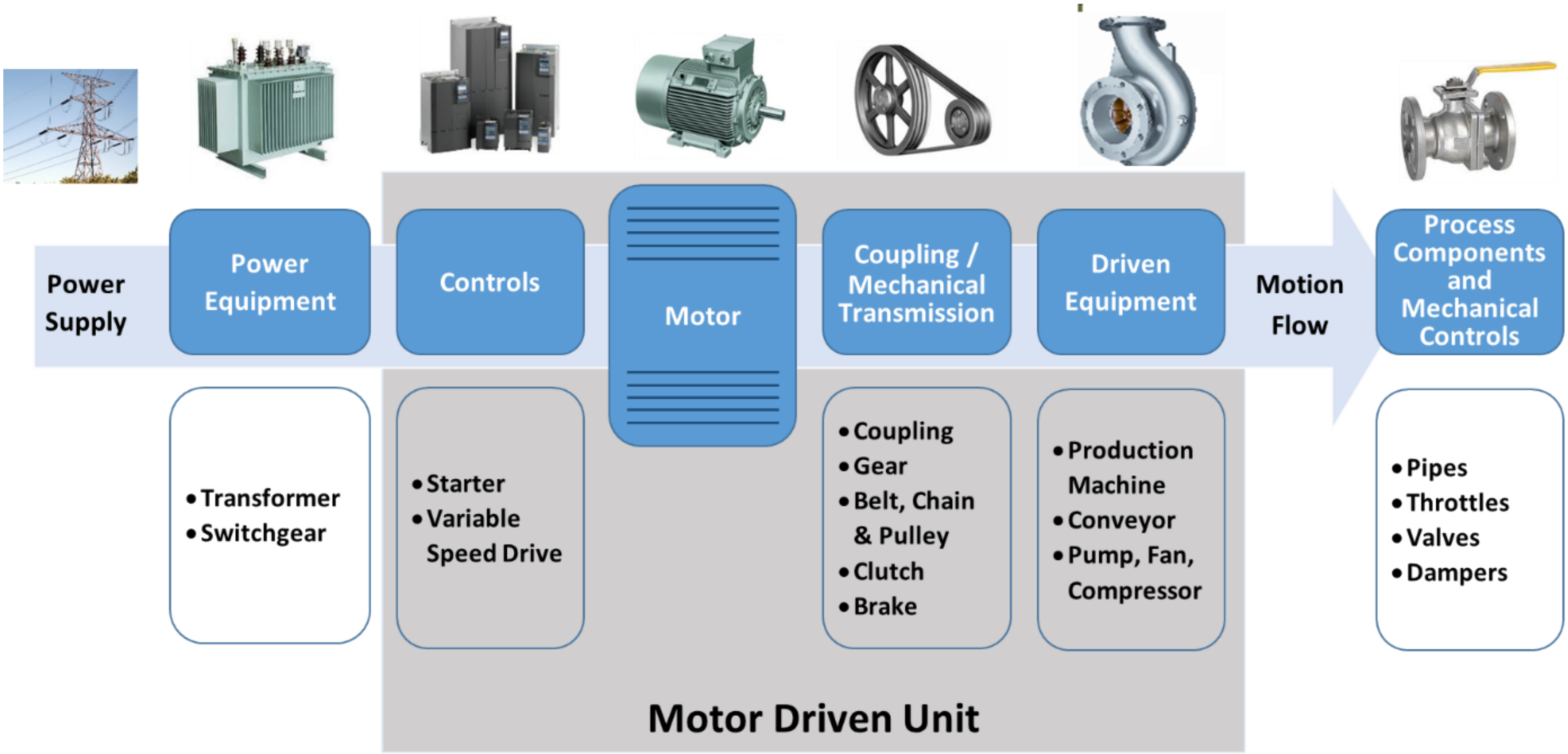
- motor efficiency
- Possibility of motor speed/torque control using a Variable Speed Drive (VSD)
- proper sizing
- power supply quality
- distribution losses
- mechanical transmission
- maintenance practices
- end-use mechanical efficiency (pump, fan, compressor, etc).

Motor System Design -
How to select an efficient system for your application

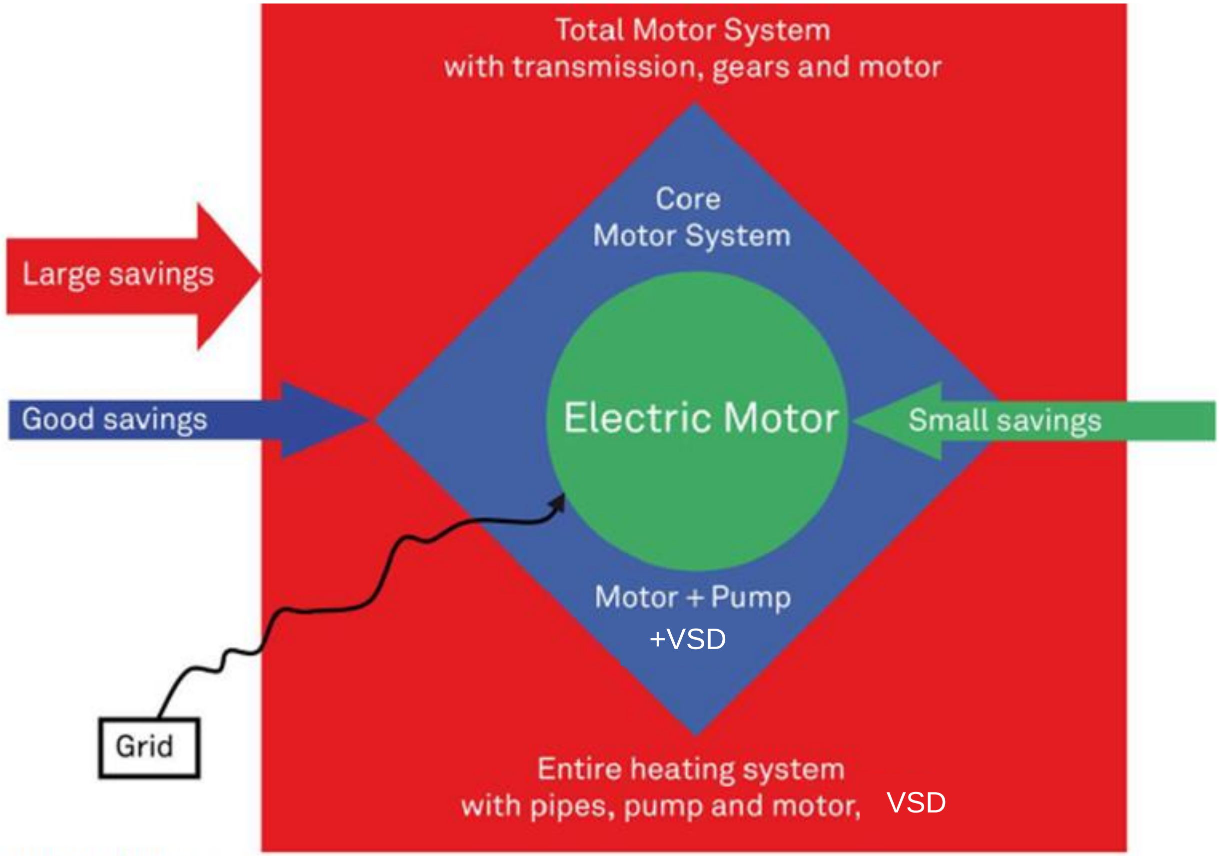
Factors to be considered :

- The mechanical requirements of the driven load, namely the required torque and speed.
- Time variation of these requirements.
- Environmental (e.g. temperature and altitude) considerations.
- **All components in the system must have high efficiency**

Motor Systems Integrate Key Components

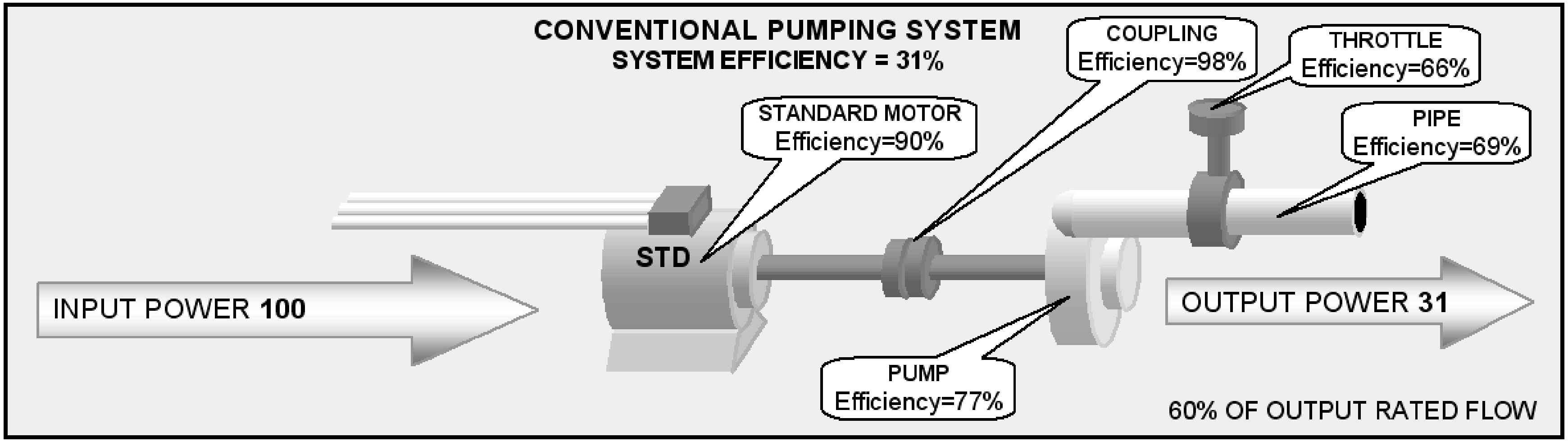


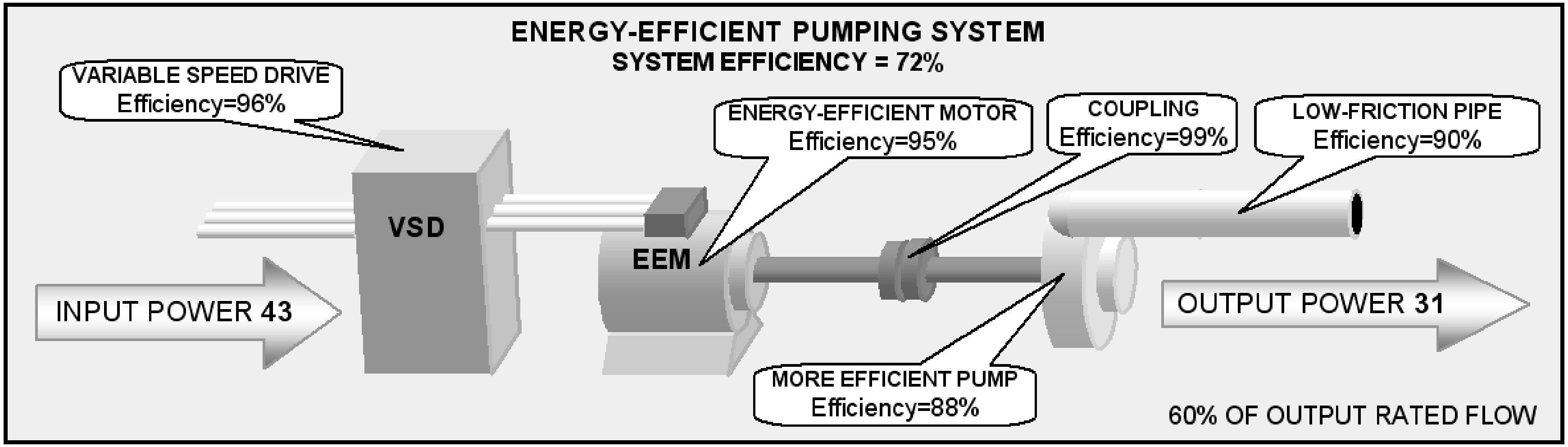
Main Sources of Motor Systems Energy Savings



Source: A+B International, 2008.

Example of Motor System Energy Savings





Motor systems savings potential - EU

In the EU, 200 TWh of savings can be achieved by using EE motor systems

6% of total electricity consumption of EU

35 nuclear power plants – 1000 MW

(70% load factor)

130 fossil fuel power plants – 350 MW

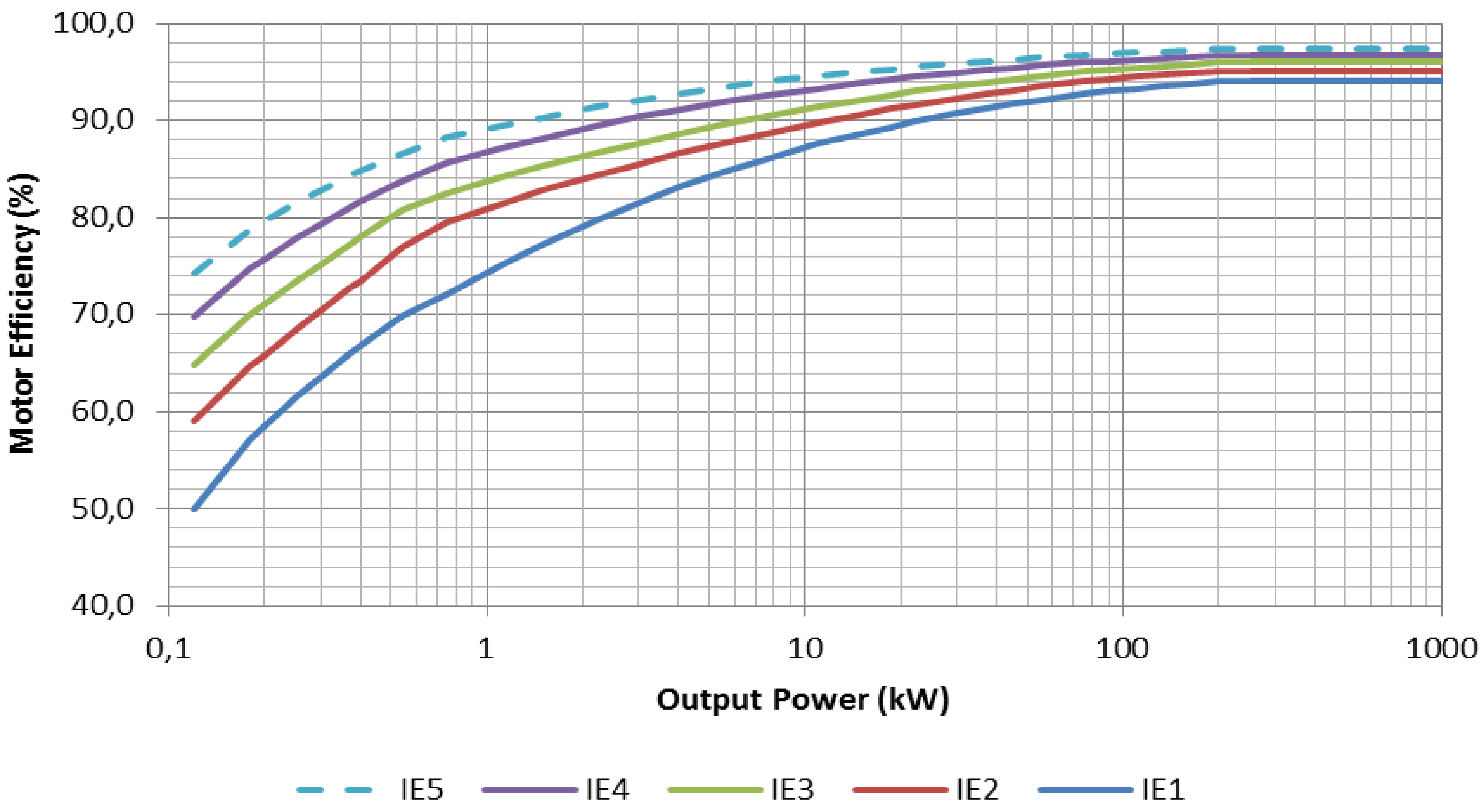
(50% load factor)

80% of the wind power capacity installed by the end of 2014 - 284 TWh

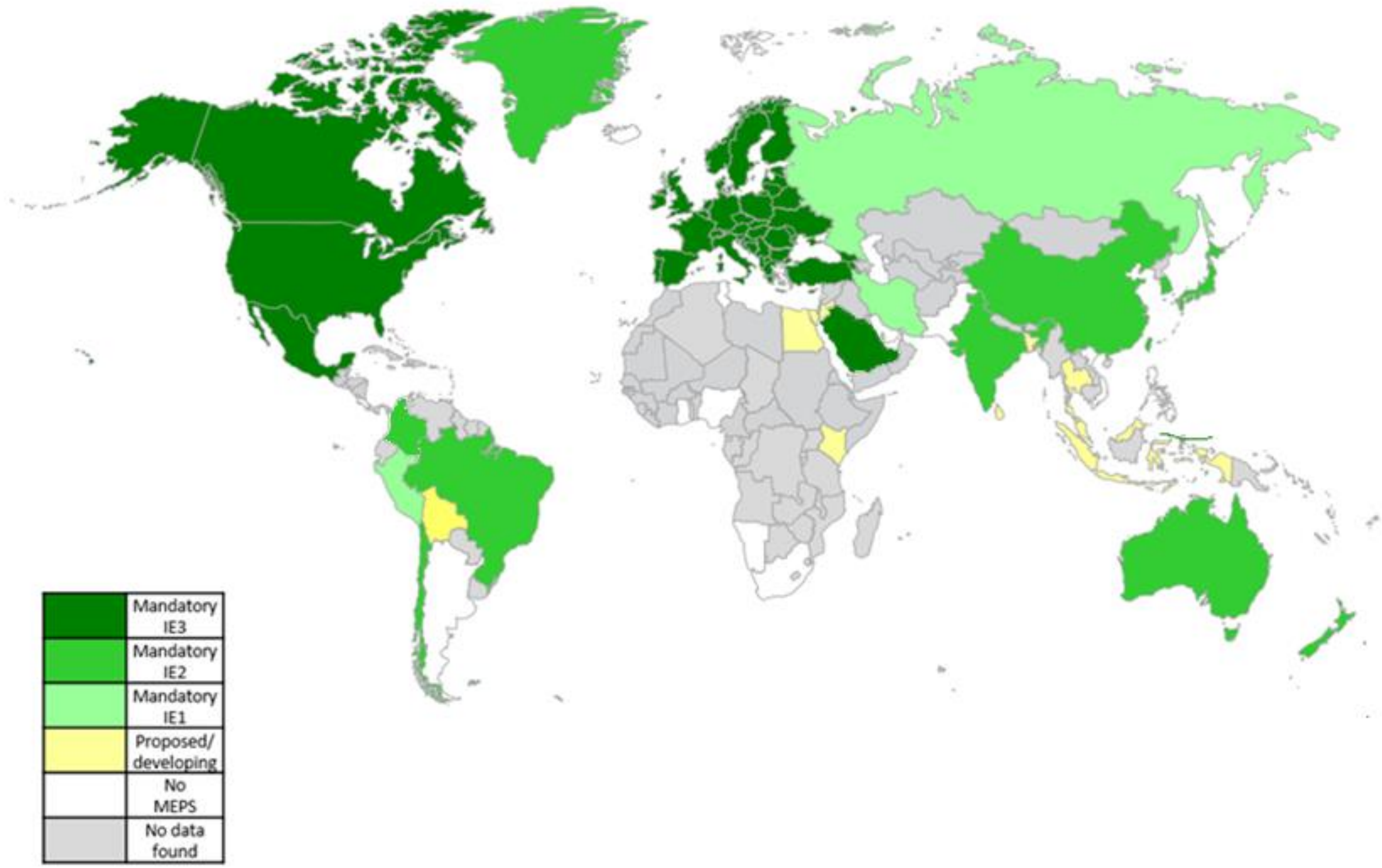
500 000 new electric cars

Efficiency levels in the IEC 60034-30-1 (2014) classification standard

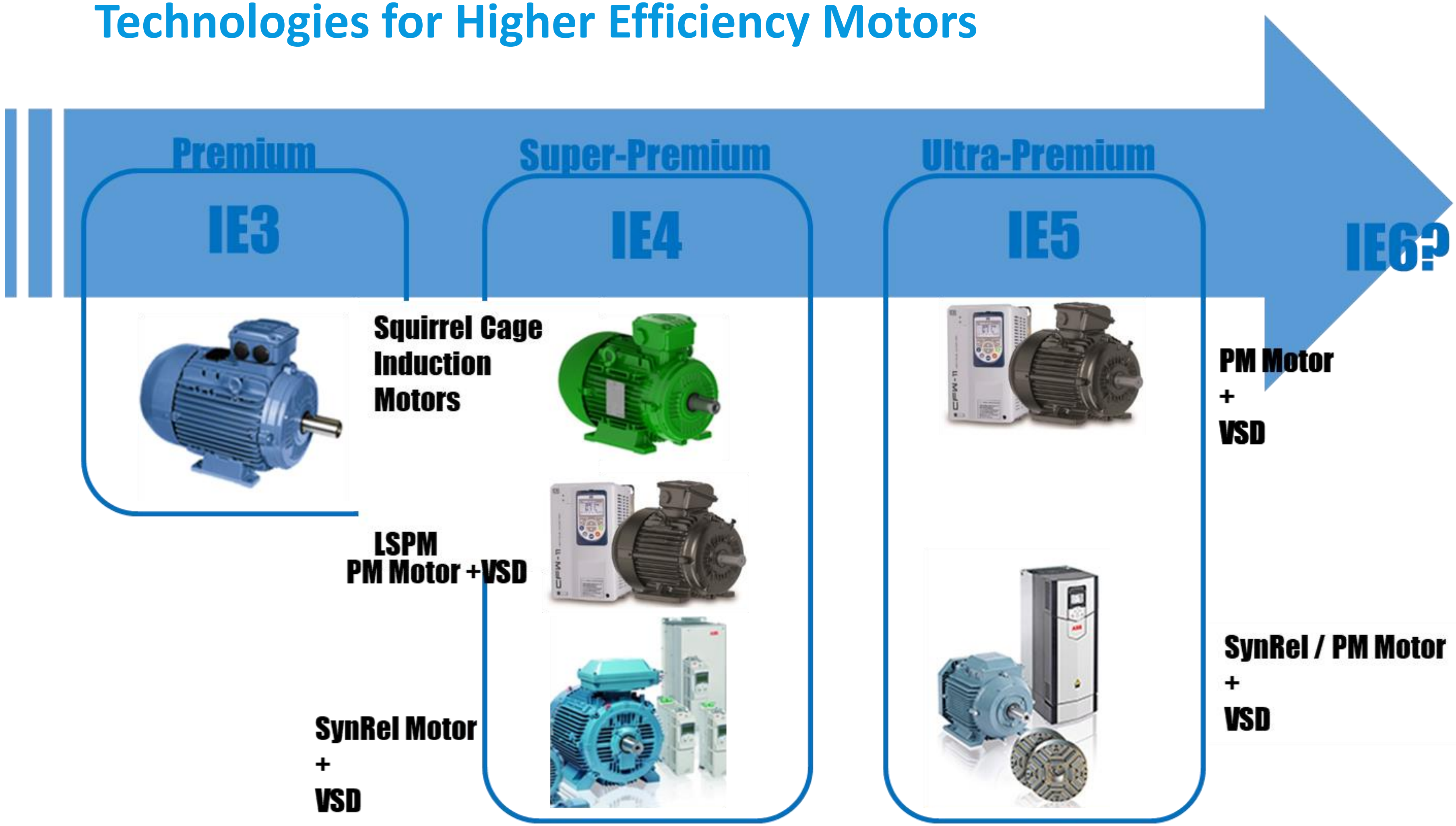
50 Hz, 4 poled motors



Worldwide Motor Minimum Efficiency Performance Standards (MEPS)



Technologies for Higher Efficiency Motors



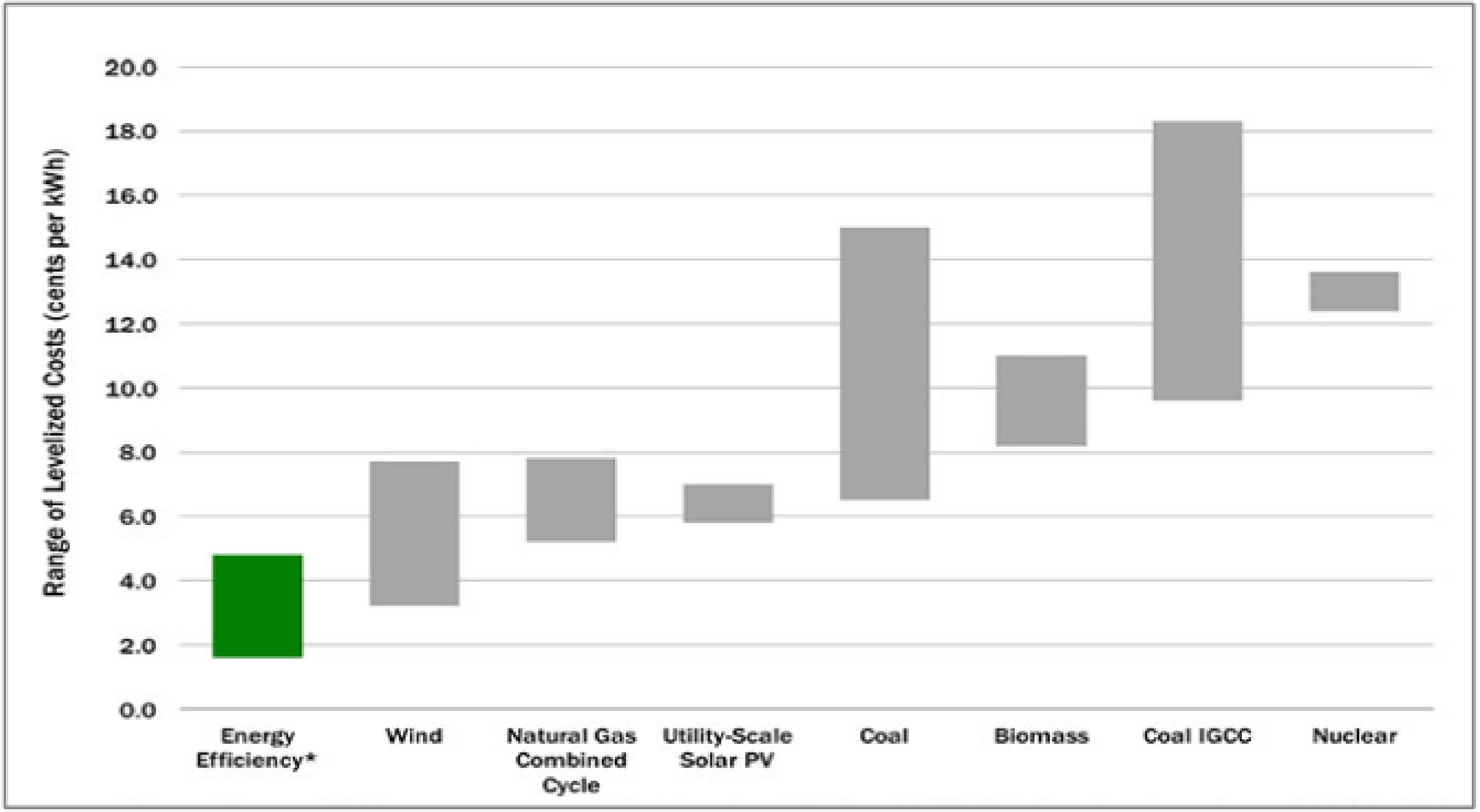
Advantages of high efficiency motors

- Energy savings
- Reduced energy costs
- Better materials and manufacturing techniques
- Improved reliability and reduced maintenance costs;
- Longer lifetime (lower operating temperature);

Advantages of Variable Speed Drives (VSDs)

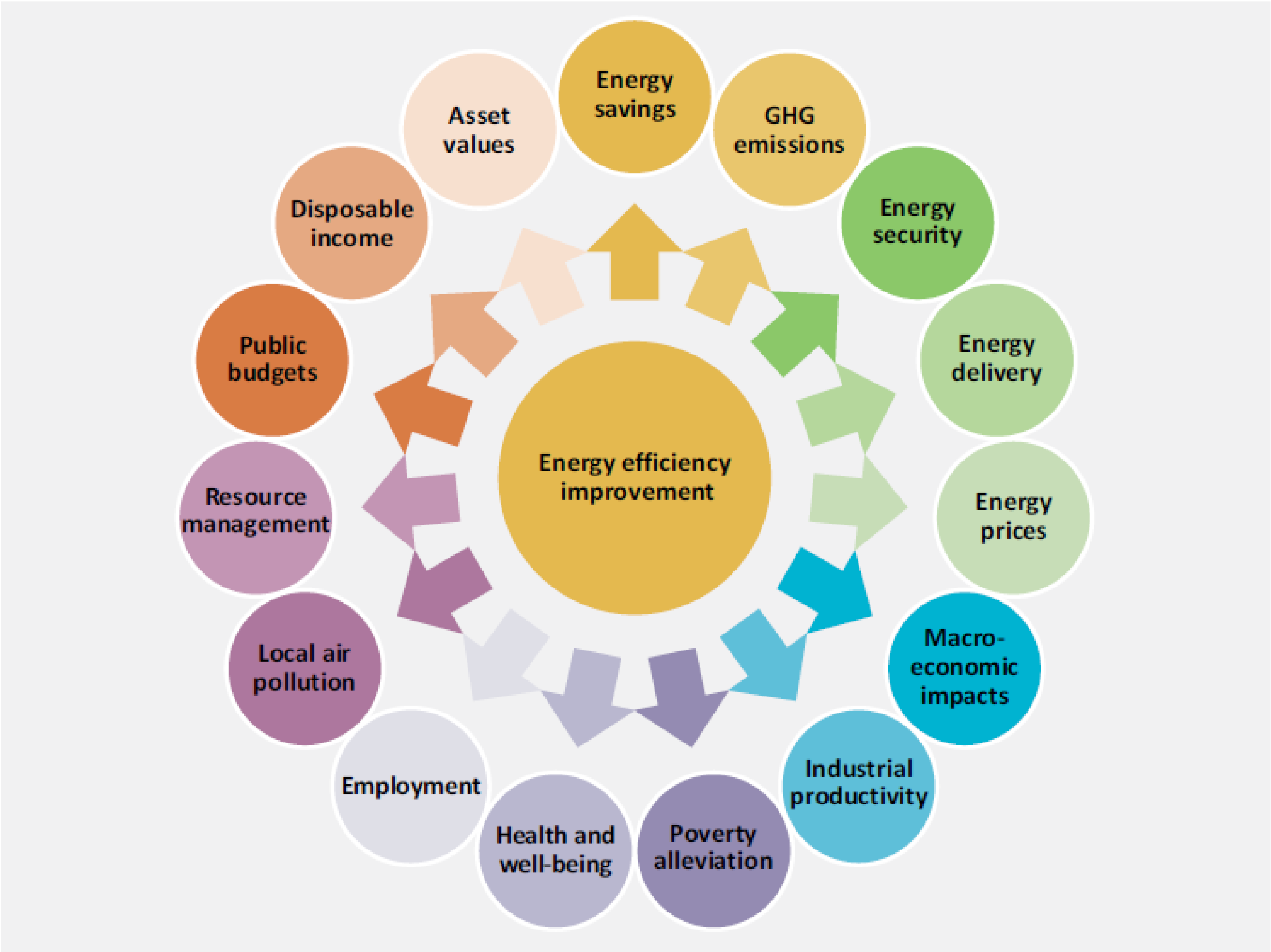
- Energy savings associated to the speed control;
- Improvement of the dynamic performance of induction motors;
- High efficiency of the VSDs (96-98%) and high reliability;
- High power factor (if active front end is used);
- Small size and location flexibility;
- Soft starting (savings!) And controlled/regenerative braking;
- Motor protection features;
- Lower acoustic noise and improvement of the process control;
- Less wear maintenance needs of the mechanical components.

Energy Efficiency Costs Much Less Than Generating Electricity (USA)



Source: ACEEE, 2016

The multiple benefits of energy efficiency



Source: IEA, 2014

Energy efficiency benefits for emerging economies

- Access: Energy efficiency can help countries to expand access effectively enabling them to supply power to more people through the existing energy infrastructure.
- Energy security: as a domestic measure that reduces reliance on imported energy, energy efficiency programs are typically a key part of national efforts to improve the security of future energy supplies.
- Development/growth: Many energy efficiency measures are cost effective. Costs vary among technologies and countries where energy efficiency measures are implemented, but often are only one-quarter to one-half the comparable costs of acquiring additional energy supply. Thus, energy efficiency has a variety of positive impacts that support economic growth, for example by improving industrial productivity and reducing fuel import bills.

Energy efficiency benefits for emerging economies

- Affordability/poverty alleviation: Energy efficiency can increase energy affordability for poorer families by reducing the cost of lighting, heating, refrigeration. etc. (IEA, 2015)
- Local pollution: Energy efficiency (both supply side and end-use) can help to reduce the use of energy – and lower associated emissions – while supporting economic growth.
- GHG emission mitigation: Realizing the economic potential of energy efficiency is a central pillar of a cost-effective strategy to mitigate climate change and achieve a peak in global greenhouse-gas emissions by 2020 (IEA, 2015). According to IEA's estimates, to achieve the 2 degree target, annual emissions need to be reduced by over 10 $GtCO_2$ by 2050 compared with business as usual, in which the contribution of energy efficiency (both from end-use sector and power sector) will exceed 40%.

Benefits of energy efficiency in industrial companies

- Energy Savings / Cost reduction;
- Improved operational reliability and control;
- Reduced operational and maintenance expenses
- Peak power reduction;
- Ability to increase production without requiring additional, and possibly constrained, energy supply;
- Avoidance of capital expenditures through greater utilization of existing equipment assets;
- Recognition as a “green company”, with positive feedback from general public and customers
- CO_2 emission reduction
- **Companies engaged in environmental sustainabillity have proven to be more profitable**

Benefits of energy efficiency in industrial companies

Operations and Maintenance	Production
Reduced maintenance costs	Reduced product waste
Reduced purchases of ancillary materials	Increased Production
Reduced water consumption	Improved product quality
Lower cooling requirements	Increased production reliability
Reduced labor costs	Shorter process/cycle time
Lower costs of treatment chemicals	
Work Environment	**Environmental**
Increased worker safety	Reduced hazardous waste
Reduced noise levels	Reduced dust emissions
Improved workstation air quality	Reduced waste water output
	Reduced CO, CO_2, NO_x, SO_x emissions
Other	
Achieved rebate/incentive (one-time)	
Reduced/eliminated demand charges	
Reduced/eliminated rental equipment costs	
Avoided/delayed costs (one-time)	

Benefits of energy efficiency in industrial companies

- All of these benefits contribute to improved productivity and value creation for the company.
- Relatively few assessments have attempted to measure these impacts concretely but current results point to additional value ranging from 40% to 250% of the value of energy savings (IEA, 2014).

Information, behavioural, organisational and market barriers

- **INFORMATION**-Companies have limited knowledge and access to information about new and existing energy saving technologies.
- **RISK** -Companies may perceive technical and operational risks of implementing energy efficiency projects due to unfamiliarity with energy-reducing technologies and practices relative to core business projects.
- **ORGANIZATIONAL** -Professional and functional boundaries within the organisation limit the collaboration required to identify and support energy efficiency
- **MARKET PRICES-** Energy prices and taxes are subsidised in some countries in the industrial sector; therefore, companies may not pay the full cost of their energy use and have less incentive to reduce consumption.

Financial Barriers

- Companies lack access to capital
- Investments in energy efficiency projects do not meet financial criteria within companies (especially in countries where interest rates are high)
- Businesses like to use capital and resources to grow and expand production. When they want to reduce costs, they want to do so without spending too much capital. Companies will often only fund projects with an 18-month to two-year payback or less, unless it has a productivity or growth outcome as well.
- Financial environment is not very favourable for investments in energy efficiency due to a lack of familiarity of financial institutions with financing energy efficiency projects and measures;

Financial Barriers

- Risk associated with energy efficiency projects is viewed as high by financial institutions;
- Low awareness about non-energy benefits (NEBs) is viewed as the main barrier to increasing the rate of energy efficiency investment followed by a lack of understanding of energy efficiency financing by banks and other financial institutions; administrative barriers and bureaucracy; and low energy prices.

Main Strategies to overcome Barriers

- Rebates (e.g. covers part of the investment) and low-interest loans for energy efficiency projects are viewed as the most important factors to increase energy-efficiency project investment viability;
- Tax incentives (e.g. accelerated depreciation)
- Stricter energy-efficiency standards;
- Training and awareness programmes;
- Improved legislation and de-risking of investments through Government support programmes.

The multiple benefits approach

The multiple benefits approach extends the reach of energy efficiency beyond the well established impacts of energy demand reduction and reduced GHG emissions, revealing its potential to deliver a host of other benefits to the economy and society.

Including Non-Energy Benefits (NEBs) in the decision-making process may be one way to meet and hopefully overcome known barriers for energy-efficiency investments.

Incorporating NEBs information into the engineering analysis when making a decision about an energy-efficiency investment, may have a significant effect upon the decision-making process of a given project.

Categorisation matrix for NEBs

- NEBs with a high quantifiability level can be introduced earlier in the decision making process as they are easier to compare analyse.

- NEBs of a low quantifiability level, especially those of a strategic character, can serve as extra arguments at a later step in the decision-making process to select between similar investment opportunities.

Categorisation matrix for NEBs

Quantifiability	Short term	Long term
High	Increased production, reduced operating time, improved equipment performance, shorter process cycle times, reduced operational costs, reduced amount of raw material	Reduced labour costs, reduced maintenance costs, reduced wear and tear on equipment and machinery, extended life of equipment, reduced scrap/rework costs, improved reliability
Medium	Productivity gains, improved efficiency, improved product quality, increased capacity, improved capacity utilisation, improved temperature control, lowered cooling requirements	Reduced waste and waste costs, reduced emissions, reduced cost of environmental compliance, reduced need for engineering controls, delaying or reducing capital expenditures, decreased liability, increased asset values, improved process control
Low	Improved worker safety, improved work environment, decreased noise, improved lighting, additional space, reduced need for personal protective equipment, improved air quality	Improved public image, increased job satisfaction, improved worker morale, competitive advantage, improved customer satisfaction, reduced risks (legal, energy price, energy supply, commercial), health benefits

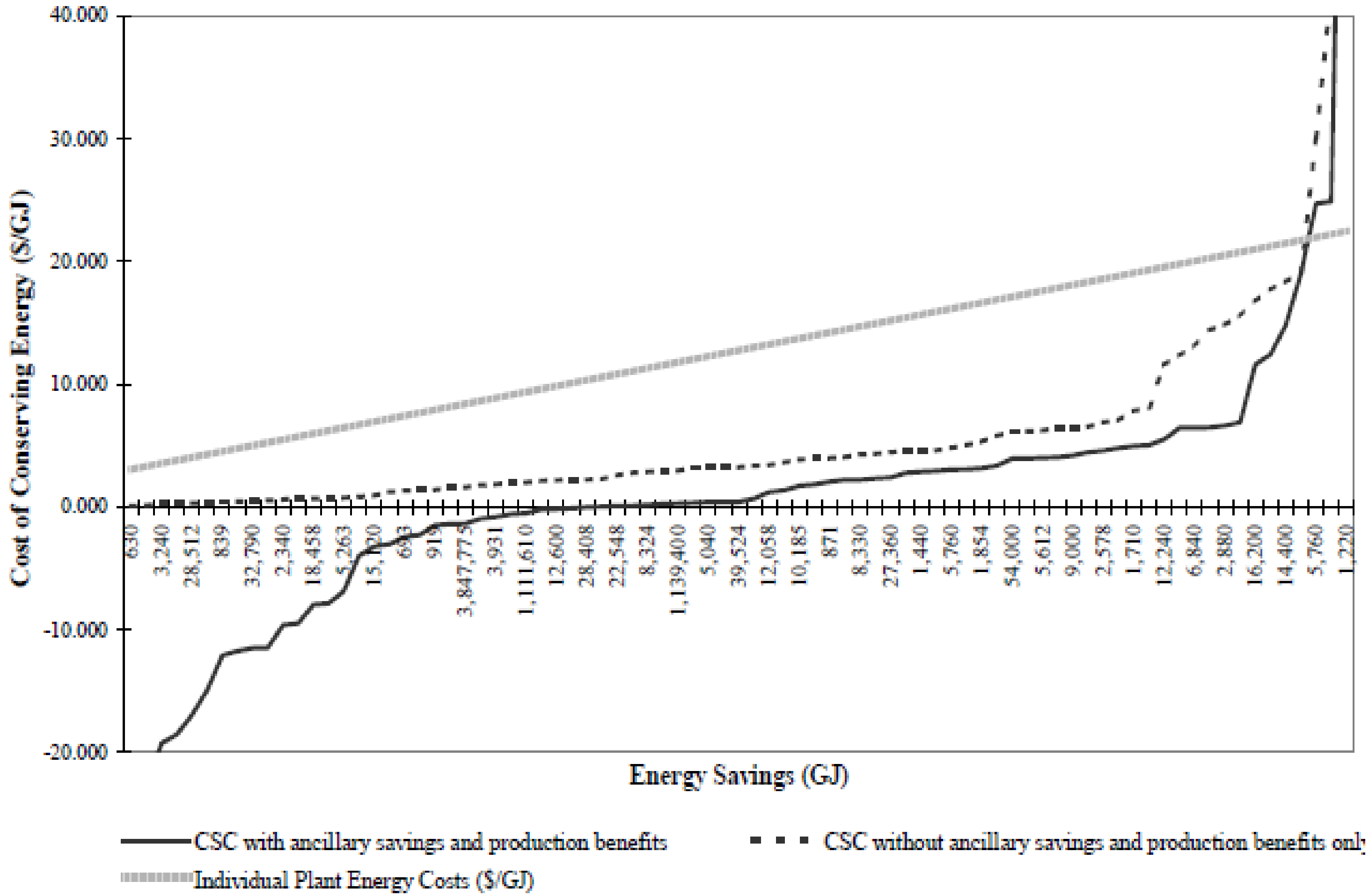
Time

The multiple benefits approach

An analysis of 52 monetized case studies (Worrell et al. 2003) reveals a 4.2-year payback time based only on the energy savings. This falls to a 1.9-year payback time for projects when including the full productivity impacts of a project .

Lung et al. (2005) analyse 52 case studies that were developed by the U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy (EERE) between 1998 and 2004, for which Multiple Benefits are quantifiable .

The multiple benefits approach
Conservation Supply curves



MULTIPLE BENEFITS CASE STUDY – Steel Industry

- Since 2006, ArcelorMittal has saved more than $257 million annually on energy costs through a wide range of efficiency measures, including installing variable speed drives, energy monitoring systems, LED lighting, and combined heat and power systems.

- ArcelorMittal's before the company installed variable speed drives, it was replacing at least three motors and fans every year to the tune of $200,000 annually. When equipment went down, operations were delayed causing further expenses. Plus, replacing equipment required employees to work in difficult and potentially dangerous situations.

- Now, with variable speed drives installed, they haven't had to replace a motor or fan in years. Investing in **energy efficiency reduces maintenance, downtime, saves money, reduces delays, makes equipment run longer and even improves worker safety,"** he said.

Lehigh Southwest Cement Company Case Study

Compressed Air System Improvement Saves Energy at a Lehigh Southwest Cement Plant

- Improved the compressed air system at its cement plant in Tehachapi, California.
- The project stabilized the system pressure, replaced some worn compressors with more efficient units, and reduced compressed air waste.

Source: https://www.nrel.gov/docs/fy04osti/34307.pdf

Background

- The Tehachapi plant needs compressed air to serve dust collectors, cylinders, air knives, and pneumatic clutches, all of which are essential for cement production.
- Before the project, four rotary-screw compressors totaling 1,445 horsepower (hp) served the compressed air system.
- The three largest compressors, two 550 hp and one 220 hp unit, served the main plant system; the fourth, a 125 hp compressor, was dedicated to air knives.
- Before the plant was ready to implement the project, the 125 hp compressor failed and the plant depended on the three existing units and a 300 hp rental compressor.
- The system experienced severe pressure fluctuations, poor air quality, increasing energy and maintenance costs, and periodic compressor shut downs that interrupted production.

Improvement measures

- Stabilize the system pressure with the installation of a pressure/flow controller (P/FC) along with a 19 m^3 storage receiver.
- Remove 220 hp compressor
- Install two new 350 hp rotary-screw units
- Compressors were linked together and programmed to automatically rotate each unit every 24 hours to equalize compressor operating time and to fully load the lead compressor with the second unit trimming and shutting off as necessary.
- The plant's air demand is satisfied by baseloading just two compressors, one 550-hp and one 350-hp unit, and operating a single 350-hp unit in trim mode.
- Improve the intake air conditions and the supply-side distribution piping (e.g. filters, reconfigured piping
- Repaired the malfunctioning aftercoolers.
- Reduce compressed-air waste in the demand side of the system (e.g. replace condensate traps with six high-efficiency drain traps, located and repaired the largest leaks in sub-headers, drop piping, and hoses.

RESULTS

- Annual compressed air energy savings are 900,000 kWh, representing a 13% decrease in compressed air energy consumption.
- Energy cost savings of **$90,000** per year
- An additional **$50,000** per year is saved because the plant no longer needs to rent a 300-hp compressor;
- **$59,000** per year is saved through lower maintenance costs. Furthermore, the plant has not had any production shut downs that can be linked to the compressed air system.
- With the incentive payment from the local utility **($90,000**), the project's total cost is **$327,000**.
- With total annual savings of **$199,000**, the simple payback is less than 20 months.

Gracias !