Energy efficient electric motor systems in Indonesia

Mid-term report: quantifying the project, stakeholders feedback and preparing the next phase

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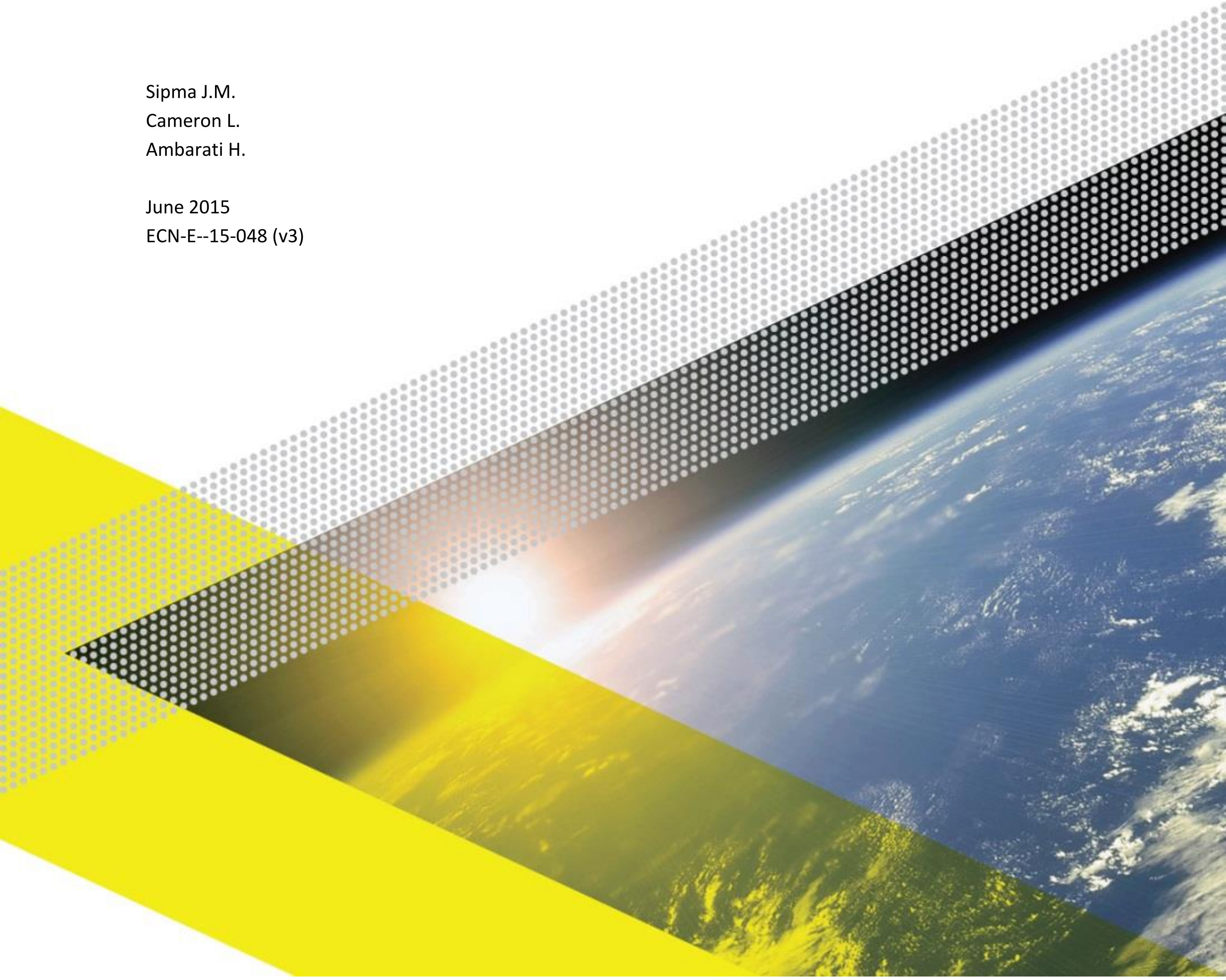

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Summary

More than 60% of electricity demand in Indonesia's industrial and commercial sectors comes from electric motors. Many of these are older or lower efficiency designs, often used at fixed speeds that waste power. Without any intervention, the business as usual (BAU) scenario shows that electricity consumption with the use of motors will triple by 2035 in Indonesia, as will CO_2 emissions associated with this electricity use.

There is therefore an enormous opportunity to improve the performance of these applications that Indonesia is currently pursuing. Significant savings are possible by replacing older inefficient motors by examples that perform better and by improving the general efficiency of the complete system that is driven by the electric motor. Medium and large motors, which are found in the commercial and industrial sectors, have the greatest potential for efficiency improvements, as they are relatively few in number (in Indonesia only 7% of all stock) but make up almost 75% of all electricity used by motors.

MEPS and energy efficient electric motors

For a number of years, Indonesia has been preparing to introduce Minimum Energy Performance Standards (MEPS) for these motors, regulating what type of motors are allowed to be sold in the country. However, this report shows that the benefits of introducing MEPS will be very modest, when this is the sole measure to reduce energy use from electric motor systems. Introducing MEPS at the first level of IE1 in Indonesia will give less than 1% energy savings compared to BAU. If Indonesia improves its MEPS level over time to IE4 (future European level), electricity savings would be 5%.

Assuming that the present motor stock will be replaced by the year 2035, implementing the MEPS at level IE1 will save the commercial and industrial sector on average yearly 60 mln USD (saved electricity consumption) and the government 36 mln USD (avoided subsidies), Implementing MEPS at level IE4 would increase these financial savings with a factor 7.

Broadening the scope towards electric motor driven systems
Only by considering the broader motor 'system' and taking additional steps to target efficiency improvements from these systems can large benefits be realised. The real impact of introducing MEPS for electric motors is the fact that by replacing an old motor for a new one, the opportunity is there to consider the whole 'electric motor driven system' (EMDS). This is where the most energy saving opportunities lies.

Most electric motors drive pump, fans and compressed air systems. Other important parts of an electric motor driven system could be variable speed drives and the transmission between motor and driven device. The four industries with the highest savings potential for energy efficient electric motor systems are iron and steel, textile and clothing, food and beverage, and cement.

These investments are in many cases profitable and pay themselves back within 3 years' time. Typically the purchase price of an electric motor is very small compared to the total lifetime costs; in the order of 2% of lifetime costs, at 4000 running hours a year.

However, just as in many other countries, a number of barriers prevent these economically rational investments from being made. These barriers include of lack of awareness, investment decisions based on purchase costs and a large stock of old replacement motors. More specifically related to Indonesia, are barriers that relate to subsidized electricity prices, the import of low-cost Chinese motors, oversizing, motor rewinding policy, continuation of industrial production lines, and challenges of regulatory enforcement.

To overcome these issues, policies that target complete systems, should supplement MEPS. We estimate that these additional policy tools could achieve an *additional* 15%-point efficiency improvement beyond the use of MEPS only; i.e. up to 20% of electricity use associated with motors across Indonesia. The EMDS policy approach would quadruple the financial savings of a IE4 MEPS-only program.

Needed investment and installation workforce
To replace the present stock of electric motors under a MEPS programme, will need up to 2035 an average yearly direct investment of 190 to 240 mln USD, depending on IE-level. We assume that only the larger electric motors will need external installing engineers. Since this counts only for 10% of the total stock that should be replaced, the total needed external workforce is relatively small and has been calculated as 325 external engineers with a full-time job.

When a EMDS policy approach is added, the needed direct investment will increase with a factor 8. We assume that as well systems driven by relatively smaller electric motors will need external engineer. Since these additional measures are as well more complex and time consuming to implement, the total needed man-years will increase with a factor 18.

Policy tools

Best practices of other countries show that, besides MEPS and energy labels, the following elements can be part of a successful approach targeting several stakeholders:

- Voluntary agreements with industry
- Energy management programmes
- Energy audit programmes
- Company motor policies
- Financial incentives
- Raising awareness and providing information

These tools do not work independently from each other, but are highly complementary. The interaction between these instrument, and the way they strengthen each other is important to assess, just as the interaction with the different stakeholders.

This project is working with the Ministry of Energy and Mineral Resources to study what a national policy framework for efficient motor systems should look like, including which additional policy tools are most appropriate for Indonesia and what is required to implement these measures.

Until now the project has been developing the evidence base and network of stakeholders that will be used for policy design and feedback. The second phase of the project will work with these partners to prepare of a detailed proposal for a policy framework, which includes the evidence base for taking action, describes policy measures and their costs, and an approach to monitoring and reporting outcomes.

Version control:

- Version 01, June 2015
- Version 02, December 2015. Table 9 and Table 25 correction of energy units in column headings
- Version 03, May 2016. Table 5 lower part, correction of energy unit

Ringkasan

Lebih dari 60% konsumsi energi listrik oleh sektor Industri dan sektor komersial di Indonesia berasal dari motor listrik. Sementara, banyak dari motor listrik tersebut tergolong sudah tua atau efisiensi penggunaan energinya yang rendah, dan sering juga digunakan dengan kecepatan yang konstan yang berarti penggunaan dayanya boros. Jika hal ini dibiarkan tanpa adanya intervensi kebijakan, disebut skenario *Business as Usual* (BAU), maka konsumsi energi listrik dari penggunaan motor lisrik di Indonesia akan menjadi tiga kali lipat pada tahun 2035, demikian juga emisi CO_2 dari konsumsi energi listrik ini.

Banyak pilihan untuk meningkatkan performansi dari aplikasi penggunaan motor listrik di Indonesia yang tersedia dan saat ini sedang dikembangkan. Penghematan yang signifikan sangat mungkin dicapai, dengan mengganti motor-motor tua yang tidak efisien dengan yang lebih baik performansinya. Motor listrik dengan ukuran sedang dan besar yang ada pada sektor komesial dan sektor industri, mempunyai potensi penghematan yang terbesar di Indoensia. Hal ini dikarenakan jumlahnya yang tidak begitu banyak (hanya sekitar 7% dari populasi motor listrik di seluruh Indonesia) tetapi mengkonsumsi hampir 75% dari konsumsi energi listrik dari seluruh motor listrik yang ada.

MEPS dan Motor Listrik yang Efisien

Selama beberapa tahun terakhir, Indonesia telah dan sedang menyiapkan sebuah regulasi Standar Performansi Energi Minimum (*Minimum Energy Performance Standard*, MEPS) pada motor listrik. Standard ini akan mengatur hanya motor listrik dengan kelas efisiensi tertentu yang akan diijinkan dipasarkan di Indonesia. Tetapi, laporan ini menunjukkan bahwa keuntungan dari menerapkan MEPS tidaklah begitu signifikan jika hanya diterapkan secara sendiri atau tanpa dibarengi oleh instrument pendukung lainnya. Dengan penerapan MEPS pada kelas IE1 di Indonesia akan memberikan penghematan energi listrik kurang dari 1% dari BAU. Sementara, sejalan dengan perjalanan waktu, jika Indonesia dapat meningkatkan penerapan MEPS hingga IE4 (Level yang akan dicapai Eropa pada masa datang), maka penghematan energi yang akan dicapai adalah 5%.

Jika diasumsikan motor yang ada saat ini akan diganti sebelum tahun 2035, dengan menerapkan MEPS pada level IE1 akan memberikan penghematan pada sektor komersial dan sektor industri secara rata-rata sebesar 60 juta USD setiap tahun (berasal dari penghematan konsumsi energi listrik). Sementara pada sisi pemerintah penghematannya adalah 36 juta USD per tahun (karena berkurangnya beban subsidi). Dengan menerapkan MEPS pada level IE4 akan menaikkan penghematan secara finansial ini sebanyak 7 kali lipat.

Perluasan cakupan ke sistem penggerak motor
Keuntungan yang signifikan hanya akan didapat dengan dengan mempertimbangkan sistem motor listrik secara keseluruhan dan menggunakan langkah langkah tambahan. Impak yang nyata dalam mengimplementasikan MEPS adalah mengganti motor yang lama dengan motor baru yang lebih efisien, sementara keuntungan penghematan yang lebih besar akan didapat jika yang diperhatikan adalah sistem pengggerak secara keseluruhan dimana motor adalah salah satu komponennya. Hal inilah yang merupakan potensi penghematan yang lebih real.

Motor listrik umumnya digunakan untuk mengerakkan pompa, fan, dan sistem kompresi udara. Beberapa komponen penting dari sistem penggerak motor listrik adalah pengatur kecepatan (*Variable Speed Drives* atau disingkat VSD) dan sistem transmisi antara motor dengan komponen yang digerakkan. Ada empat sektor industri yang mempunyai potensi penghematan yang besar jika menerapkan sistem motor yang efisien, yaitu industri besi dan baja, industri textile dan pakaian, industi makanan dan minuman, dan industri semen.

Investasi untuk peningkatan efisiensi sistem motor di industri-industri ini, pada banyak kasus adalah menguntungkan dan mempunyai masa pengembalian (*pay back time*) hanya sekitar 3 tahun. Sebagai fakta, harga pembelian motor listrik adalah kecil jika dibandingkan dengan biaya operasional selama hidup motor. Sebuah motor listrik yang beroperasi selama 4000 jam setahun, biaya pembelian hanya sebesar 2% dari biaya operasional.

Meskipun menguntungkan, sejumlah masalah harus dihadapi untuk membuat investasi yang sangat logis ini menjadi kenyataan. Fakta ini adalah masalah yang sama pada banyak negara. Beberapa masalah yang sudah diidentifikasi antara lain adalah kurangnya kesadaran, keputusan investasi yang dibuat berdasarkan harga pembelian, dan banyaknya jumlah stok motor pengganti yang tua. Secara spesifik, untuk Indonesia terdapat hambatan tambahan seperti harga jual listrik yang masih disubsidi, adanya impor motor listrik kualitas rendah dari China, kapasitas motor yang terlalu besar, kebijakan mengganti kumparan motor (*rewinding*), keberlanjutan garis produksi pada industri, dan tantangan penegakan hukum.

Untuk menanggulangi isu-isu, kebijakan-kebijakan yang menargetkan sistem motor listrik secara menyeluruh, sebaiknya mendampingi MEPS. Berdasarkan estimasi yang kami buat, paket kebijakan pendukung ini dapat mencapai tambahan 15% peningkatan efisiensi dibandingkan dengan hanya menggunakan MEPS. Sehingga secara total akan dapat dicapai pengurangan konsumsi energy listrik sebesar 20% dari listrik yang digunakan oleh seluruh motor listrik yang ada di Indonesia. Kebijakan dengan pendekatan EMDS akan meningkatkan potensi penghematan secara finansial empat kali lipat jika dibandingkan dengan kebijakan hanya dengan MEPS level 4.

Kebutuhan Investasi dan Tenaga Kerja untuk Pemasangan

Dengan menggunaan kebijakan MEPS, untuk mengganti motor yang ada saat ini, sampai tahun 2035 akan dibutuhkan biaya investasi langsung rata rata sebesar 190 sampai 240 juta USD per tahun, tergantung kepada kelas IE yang diterapkan. Kita menggunakan asumsi bahwa hanya motor listrik dengan kapasitas besar yang membutuhkan engineer dari luar industri untuk melakukan pemasangan (tenaga luar). Karena di Indonesia hanya ada sekitar 10% dari total motor listrik yang akan diganti, maka total tenaga luar yang dibutuhkan akan sangat kecil dan setelah dihitung diperkirakan hanya dibutuhkan sekitar 325 tenaga luar dengan kerja full-time.

Jika kebijakan dengan pendekatan EMDS akan ditambahkan, investasi langsung yang dibutuhkan akan bertambah 8 kali lipat. Kita mengunakan asumsi bahwa sistem penggerak dengan penggerak motor yang relatif kecil juga membutuhkan tenaga luar. Karena kebijakan tambahan ini juga lebih kompleks dan membutuhkan waktu yang lebih untuk diimplementasikan, maka total tenaga kerja yang dibutuhkan akan meningkat menjadi 18 kali lipat.

Perangkat Kebijakan

Berdasarkan pengalaman terbaik dari negara-negara lain, disamping menggunakan MEPS dan label energi, beberapa kebijakan berikut menunjukkan kesuksesan yang menargetkan beberapa pemangku kepentingan:

- Perjanjian sukarela (*voluntary agreement*) dengan industri
- Program manajemen energi
- Program audit energi
- Kebijakan tentang motor pada perusahaan
- Insentif finansial
- Menumbuhkan kesadaran dan penyediaan informasi

Perangkat-perangkat kebijakan ini tidak bekerja secara independen antara satu dan lainnya, tetapi sangat saling melengkapi. Interaksi antara instrumen-instrumen ini dan cara mereka saling menguatkan sangat penting untuk dikaji. Sama halnya dengan interaksi antara para pemangku kepentingan yang berbeda.

Proyek ini bekerjasama dengan Kementerian Energi dan Sumber Daya Mineral untuk melakukan sebuah studi tentang bagaimana bentuk kerangka kerja kebijakan sistem motor listrik yang efisien yang sebaiknya ada di Indonesia. Termasuk bentuk kebijakan tambahan apa yang paling sesuai untuk Indonesia dan apa yang dibutuhkan untuk mengimplementasikan kebijakan-kebijakan tersebut.

Sampai dengan saat ini, proyek ini telah dan sedang membangun bukti sebagai dasar (*evidence base*) dan jejaring dari para pemangku kepentingan yang akan digunakan untuk merancang kebijakan dan masukan. Tahap kedua dari proyek ini akan bekerja dengan para partner tersebut untuk mempersiapkan proposal untuk kerangka kerja kebijakan yang termasuk bukti sebagai dasar untuk mengambil tindakan, menjelaskan kebijakan yang akan diambil, biaya pelaksanaannya, dan pendekatan untuk melakukan monitoring dan pelaporan dari luarannya.

1 Project introduction

1.1 Chapter introduction

This chapter introduces the project as a whole and more specific this mid-term report. Section 1.2 gives background information on the project and closes with the final objectives. Section 1.3 explains where we stand now and what we present in this mid-term report. Section 1.4 explains what can be expected within each of the four following chapters.

1.2 Background and objectives project

ECN is working with the Directorate of Energy Conservation (EBTKE), in the Ministry of Energy and Mineral Resources (ESDM), to develop a nationally appropriate mitigation action (NAMA) related to energy efficient electric motor systems. NAMAs are actions that the Government of Indonesia will take, potentially with international support, to meet its climate targets[1]. A NAMA for electric motor systems can reduce energy demand from the industrial and commercial sectors and thereby reduce subsidies, as well as improve the revenues of Indonesian companies.

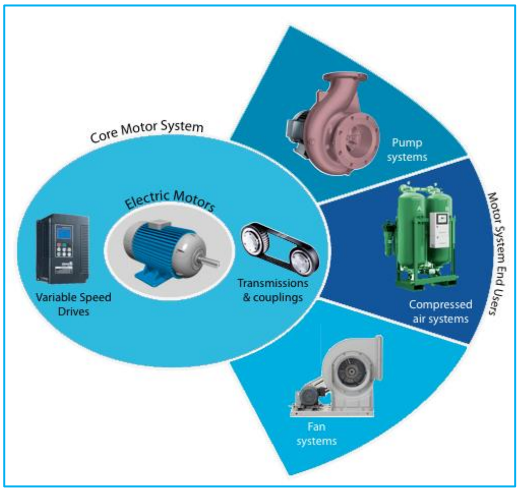
More than 60% of electricity demand in Indonesia’s industrial and commercial sectors comes from electric motors. Many of these are older or lower efficiency designs, often used at fixed speeds that waste power.

For users of electric motors, typically less than 5% of a motor's life-time expense comes from the cost of purchasing the equipment, the remaining 95% is dominated by the cost of power. More efficient motors and variable speed drives have the potential to deliver large energy savings and, therefore, financial benefits for the companies that adopt them.

[1] http://unfccc.int/focus/mitigation/items/7172.php

Motor efficiency class	International rating
Super premium	IE4
Premium	IE3
High	IE2
Standard	IE1
Below standard	IE0

Before this project started, Indonesia was in the process of introducing Minimum Energy Performance Standards (MEPS) for electric motors. Such standards describe the minimum allowable efficiency of motors that can be sold in a country.



But if you look at the whole system that is driven by the electric motor, savings can easily be doubled or even tripled. Many countries have already achieved large power and cost savings by implementing relevant policies.

In most cases, improving the efficiency of a motor system includes the following:

1. Use of energy efficient motors
2. Selecting the surrounding core components like pumps, fans, compressors, transmissions, variable speed drives, with the right type and size and high efficiency
3. Optimisation of the design and operation of the complete system

This is something that is currently being considered in Indonesia. This is more challenging than motor MEPS or labels alone, but offers much larger benefits. To achieve this, successful best practices of other countries can be used to design a suitable policy programme for Indonesia. Besides MEPS and labels, the following elements are often part of such a programme, targeting several stakeholders:

- Voluntary agreements with industry
- Energy management programmes
- Energy audit programmes
- Company motor policies
- Financial incentives
- Raising awareness and providing information

The final objectives of the project are:

- Propose government activities that could help make the shift to efficient motor systems. These should complement present and planned policies.
- Prepare a NAMA proposal with stakeholders that describes the above actions, any required support and a plan for implementation

A number of countries have experience in addressing the efficiency of electric motor systems. One of the main challenges in this project is to take best practices from other countries and to project these on Indonesia. These include practices described in guidelines from the IEA (EMSA, 2014b; Waide & Brunner, 2011) and other sources. These documents give general recommendations, drawn from countries that have already implemented the policy. This project tries to adapt these recommendations for Indonesia, taking into account e.g. the national context, cultural aspects, existing policies and market situation.

1.3 Progress and objectives mid-term report

Now, July 2015, we are halfway through the project and ready to present this mid-term report. We have done our desk research, held numerous interviews with stakeholders, collected data, and calculated the impact of energy efficient electric motors on the electricity consumption. This document summarizes the outcomes, introduces the situation in Indonesia and mentions the options for the government in tackling the intended challenge.

The objectives for this mid-term report are:

- Quantify the project in terms of energy-, and related financial savings potential
- Quantify other related aspects as needed investments and workforce
- Process stakeholders feedback; e.g. identify existing barriers and existing policies and activities that may be relevant for the final objectives

Please visit our project website for more information, including previous written documents (English and Bahasa Indonesia) and a Worksop presentation: www.ecn.nl/projects/ee-motors-indonesia

1.4 Report structure

The report is broken down in the following chapters:

- Chapter 2 starts with looking at International literature on energy efficient electric motors and their driven systems. In chapters that follow we will use this information to calculate savings potential for Indonesia.
- Chapter 3 looks at the energy consumption of current electric motors in Indonesia, and the related savings potential when systems would be improved.
- In Chapter 4 we try to get a better quantitative feeling for each (industrial) subsector in terms of electricity consumption and savings potential. This will help us as well prioritising the next phase.
- Chapter 5 proposes a general strategy to form a National Policy Framework for improved electric motor systems and introduces available policy tools to realize savings for systems. Feedback from keys stakeholders is embedded in this chapter.

2

International literature: energy efficient electric motors and their driven systems

2.1 Key messages

The focus for medium and large size electric motors

- An incredible 46% of the world's electricity is used to keep electric motors running, across a huge number of applications and sectors.
- Medium and large motors, which are found in the commercial and industrial sectors, have the greatest potential for efficiency improvements, as they are relatively few in number (in Indonesia only 7% of all stock) but make up 74% of all electricity used by motors.

Electric motor efficiency and MEPS

- Electric motors are available in four international classes , ranging from 'Standard' (IE1) up to motors that are described as 'super premium' (IE4). We have added a IE0 category that should represent the cheapest electric motors to be found in Indonesia.
- The difference between IE-classes is larger for smaller motors
- Several countries have introduced MEPS at level IE1 in the past, but most countries are now at IE2. Some already went to IE3.

Purchase price over life-time electric motor

- Electric motors often are kept running for many more years, beyond their technical-lifetime, especially when rewinding is part of a motor-policy.
- Often the purchase price of an electric motor is very small compared to the total life-cycle costs. Sources typically mention 2% only, at 4000 running hours a year

Energy Efficient Electric motor driven system (EE-EMDS)

- The real impact of introducing MEPS for electric motors is the fact that by replacing an old motor for a new one, the opportunity is there to consider the whole 'electric motor driven system' (EMDS). This is where the real saving opportunities lies.
- Most electric motors drive pump, fans and compressed air systems
- Other important parts of an electric motor driven system could be variable speed drives and the transmission between motor and driven device
- Policies that target complete systems, should supplement MEPS. We estimate that these additional policy tools could achieve an *additional* 15%-point efficiency improvement beyond the use of MEPS only; i.e. up to 20% of electricity use associated with motors.

2.2 Chapter introduction

A number of countries have experience in addressing the efficiency of electric motor systems. One of the main challenges in this project is to take best practices from other countries and to translate these to the Indonesian context. These include practices described in guidelines from the IEA, (EMSA, 2014b; Waide & Brunner, 2011) and other sources. These documents give general recommendations, drawn from countries (typically developed nations) that have already implemented the policy. This project tries to adapt these recommendations for Indonesia, taking into account e.g. the national context, cultural aspects, existing policies and market situation.

This Chapter uses international literature to get a first insight into the subject. Information that matters most has been collected and combined to serve the project. The chapter is broken down in the following way:

- Section 2.3 first looks at motors in general; what sizes and types are there and where they can be found. As well the International Efficiency class (IE-class) will be introduced
- Section 2.4 introduces technical options to make motors more efficient and the related increases in efficiency when motors are replaced with more efficient types. As well it shows at which IE-class several countries have introduced their MEPS regulation.
- Section 2.5 give insight in the purchase price over life-time of electric motors
- Section 2.6 describes the systems that are driven by electric motors and the share they have in electricity consumption of electric motors. Briefly the policy tools will be mentioned that target these systems, in addition to a MEPS programme.
- Section 2.7 continues the previous section with international literature on energy efficiency improvements that can be realised in addition to a MEPS programme.

2.3 The focus for medium and large size electric motors

About 19% of the world electricity usage goes to lighting. Lighting is a very visible form of electric consumption. We know when we waste electricity when we don't turn off lighting.

But we don't realize that 2,5 times more electricity goes to electric motor driven systems! An incredible 46% of the world electricity usage is used to keep electric motors running (Waide & Brunner, 2011).

Electric motors can be found in every sector; in the residential-, commercial-, transport- farming- and industrial sector. Obviously, the smaller ones are often to be found within the residential sector; the biggest ones within the industrial sector.

Size of electric motors

The size of electric motors is often categorized as:

- Small size motors: less than 0.75 kW
- Medium size motors: from 0.75 kW up to 375 kW
- Large size motors: above 375 kW, up to e.g. 100.000 kW

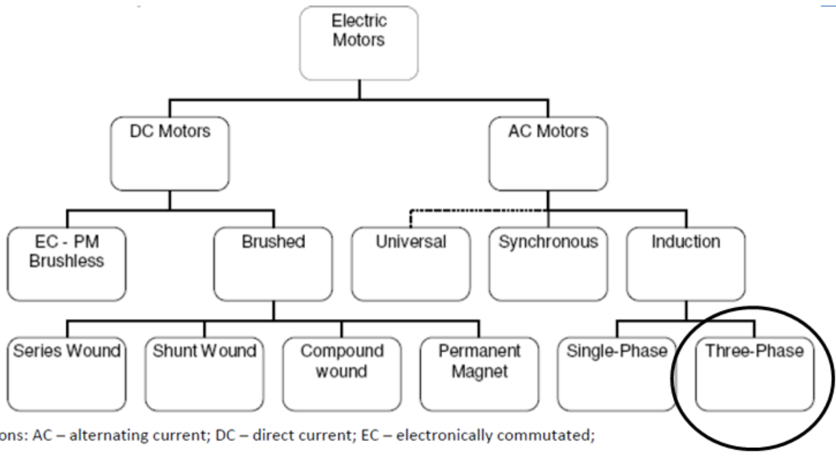
Figure 1: Different sizes of electric motors, generally world-wide

Size electric motor	small	medium	large
% total stock in use	90%	10%	0.03%
% of electricity used	9%	68%	23%
Packed machine	yes		
Specific device		yes	
Stand alone		yes	yes
Special application			yes
Residential sector	yes		
Commercial sector		yes	
Industrial sector		yes	yes
Priority for this project?	Different approach	First priority	Second priority
Strategy	Labels	MEPS and agreements	Agreements

Figure 1 gives some more general world-wide data for each size of motor, data taken from (Waide & Brunner, 2011). From this figure, we see that the medium size motors only make up 10% of the total stock, but are responsible for almost 70% of total electricity consumption. These are the electric motors that often have the focus of a project like ours. Here we talk about Minimum Energy Performance Standards (MEPS) and other regulatory and non-regulatory policy options. The smaller ones are not to be neglected, but need a different approach. These electric motors are often found in so called 'packed machines', e.g. residential fans. These devices can be targeted with a different approach, e.g. an energy label program. There are relatively only a few very large electric motors. But due to their size, they still consume 23% of the total electricity consumption and are therefore an important target in terms of energy savings. MEPS are less important here. Policy approaches as agreements on energy saving targets between the government and related industries and/or individual companies become much more important when considering these larger motors. In this study our first priority in terms of focus are the medium size motors, followed by the large ones. Around 80% of total global stock consists out of three-phase induction motors (see **Figure 2**).

Types of electric motors

Figure 2: Different types of electric motors



Abbreviations: AC – alternating current; DC – direct current; EC – electronically commutated; PM – permanent magnet.

Electric motors by International Efficiency class (IE-class)

Motor efficiency class	International rating
Super premium	**IE4**
Premium	**IE3**
High	**IE2**
Standard	**IE1**
Below standard	**IE0**

Electric motors are available in five international classes[2], ranging from 'the bad ones' up to motors that are described as 'super premium'. As shown in the table, there is an international rating system, ranging from IE1 up to IE4 (note that 'IE0' is added by us).

2 Other appliances and equipment, such as fans, fridges and irons can have similar standards and/or labels

2.4 Electric motor efficiency and MEPS

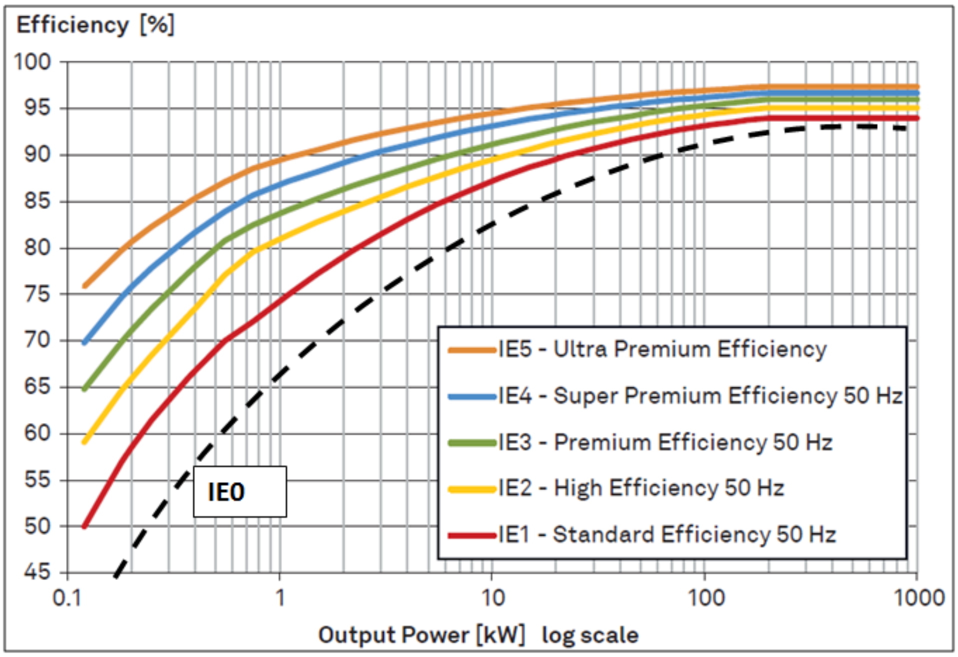
Efficiency electric motors by IE-class

Electric motors are actually quite simple devices[3]. Therefore, a few rather simple adjustments, can already make an electric motor more efficient. Energy can be lost because of electrical and mechanical resistance, that turns power into heat losses. When these become less, the motor becomes more efficient. This already can be done by using thicker electric windings and better electric insulation (less electrical resistance), and better alignment of moving parts as ball-bearings (less mechanical resistance).

Obviously there are other improvements possible as well. **Figure 3** shows the efficiency improvement of electric motors with higher IE ratings. IE1 is defined as a 'standard motor'. From IE2 onwards, motors are defined as 'high efficient'. From this figure, we can see that the difference between IE-classes is larger for smaller motors. If you come from an IE1, 1kW motor, and you change it for a IE3 motor, the gain in efficiency is about 13%. For a 10 kW motor, this would be 6%. IE0 has been added by us and represents the 'unbranded, cheap and low quality motors'; often imported from China.

Note that in reality, the efficiency of, for example, IE1 lies between the line that represents IE1, until IE2 has been reached. So, the average for a number of IE1 electric motors, will be somewhere halfway between IE1 and IE2. The same counts for the other IE classes.

Figure 3: Efficiency of IE-classes electric motors (EMSA, 2014b)



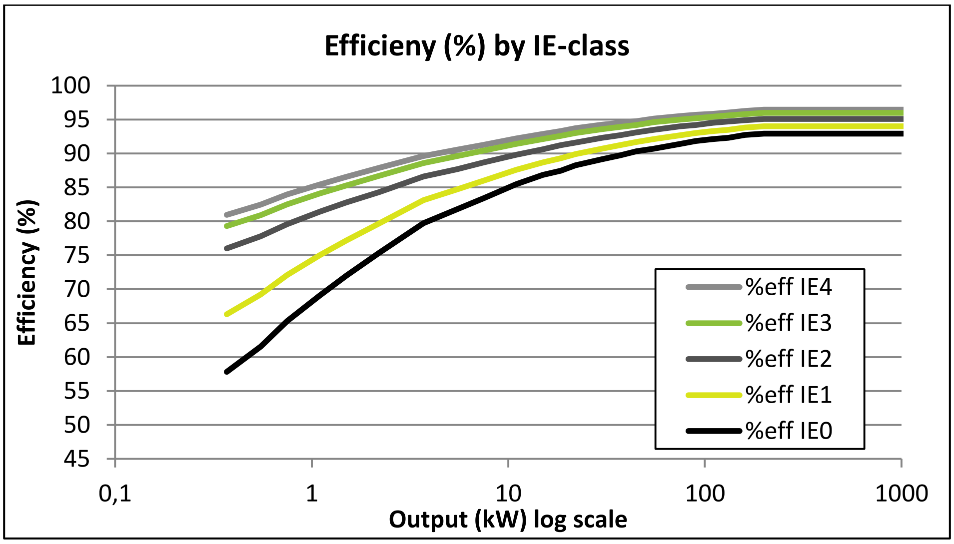
3 For an impression on how an electric motors works, see this YouTube movie (AGMLabs, 2011) for a rather simple single phase induction motor. For a three phase induction motor, as pointed in **Figure 2** as the most common motor, see this movie (Learn Engineering, 2013).

Efficiency of IE0 electric motors

The next challenge is to determine the efficiency of IE0 electric motors. How much lower would this be, compared to IE1? In this study, for a certain motor capacity, we lower IE0 with the same percentage as IE1 is lower than IE2. The result of this is shown in Appendix C, whereby the yellow cells are estimations by us. This data is turned into **Figure 4**, whereby we have added the line that represents the efficiency of IE0. Compare this figure with **Figure 3**.

As a comparison: from one unbranded 1.1 kW Chinese electric motor, we have received the efficiency test results from a Chinese testing organization. A motor like this typically shows a good performance in the beginning of the testing period. But after a while, the performance will drop. In this specific case, the efficiency dropped from about 75% (about IE1) to somewhere between 65%-70%. In **Figure 4**, IE0 gives 69%, which is at the upper bandwidth of this test result.

Figure 4: Efficiency of IE0 added as a specified class

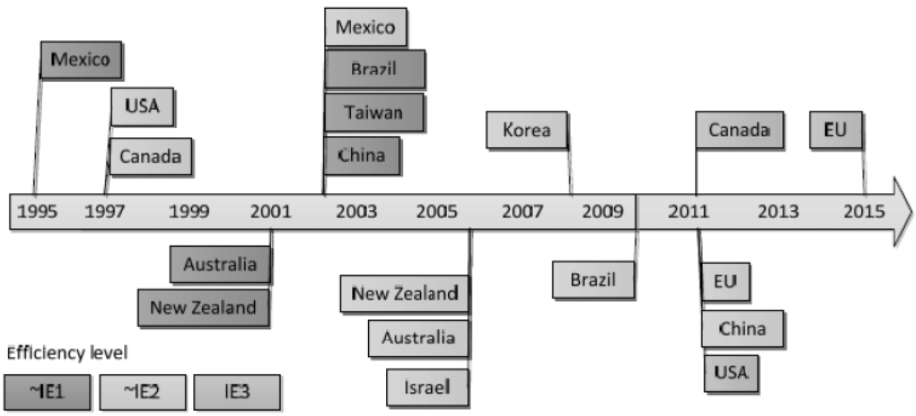


MEPS: Minimum Energy Performance Standards

In practice, countries can go over time through several stages of IE-classes when introducing Minimum Energy Performance Standards (MEPS).

Figure 5: shows that Mexico has introduced IE1 in 1995 and went to IE2 in 2003. China started with IE2 in 2012 and will go to IE3 in 2015 or 2016. The EU started with IE2 in 2011 and will go to IE3 in this year (2015).

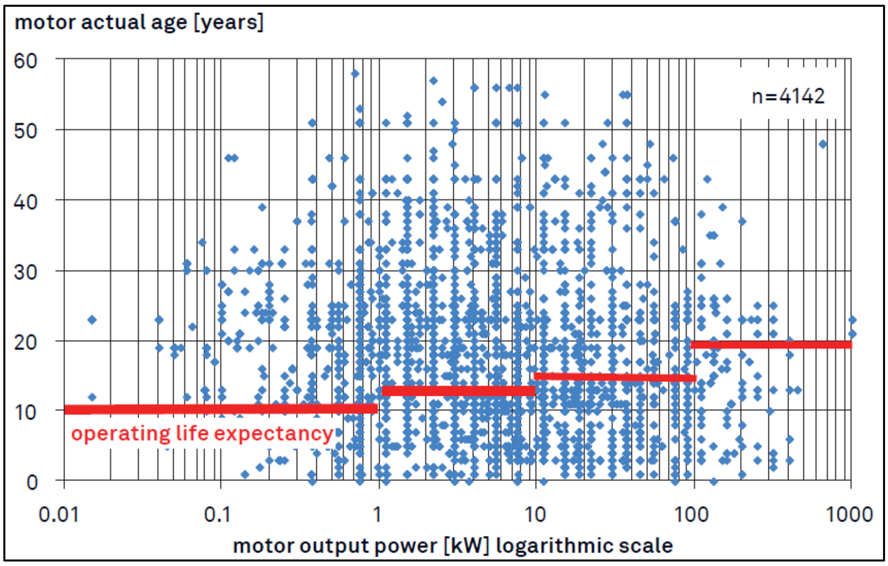
Figure 5: Mandatory IE-levels over time for several countries (UNIDO, 2011)



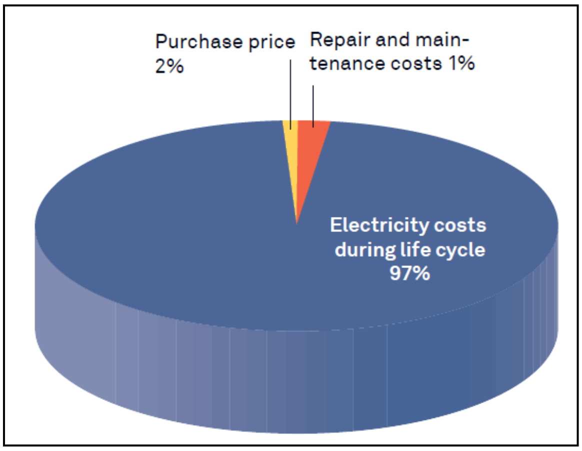
2.5 Purchase price over life-time electric motor

When regulatory policy such as MEPS is put in place, savings will not be reached quickly as motors are replaced relatively slowly. The lifetime of medium size motors is about 10 to 20 years. In reality motors could be kept running for many more years, especially when rewinding is part of a motor-policy. In **Figure 6** an analysis is given for 18 industrial plants in Switzerland (EMSA, 2014b). The conclusion here was that 56% of motors are older than their operating life expectancy. It is expected that this percentage will be higher in Indonesia due to the lack of company 'motor policies ', see next chapter on this subject.

Figure 6: Analysis of motor age in 18 Industrial plants in Switzerland (EMSA, 2014b)



In Appendix C we give our estimation for the real operating time by motor size used in further calculations.



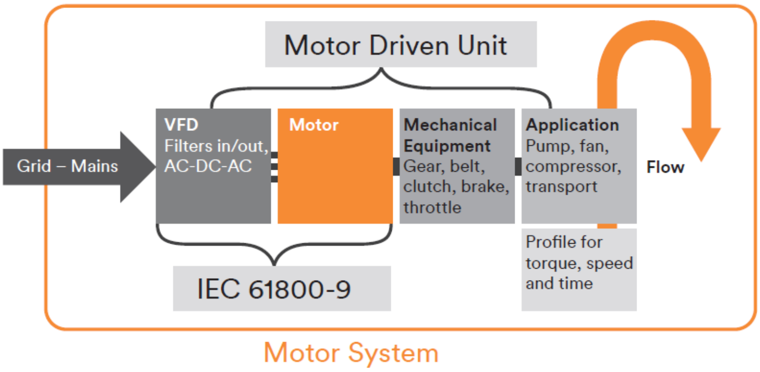
Often the purchase price of an electric motor is very small compared to the total life-cycle costs. Sources typically mention 2% only, at 4000 running hours a year and when a motor is not running longer than the expected life-time. Therefore, it is often economically beneficial to change an old motor by a new one, even before the technical lifetime has been reached (EMSA, 2014b).

2.6 Energy Efficient Electric motor driven system (EE-EMDS)

Electric motor driven systems (EMDS)

Until now we have spoken about individual motors, but energy savings could be much larger! The *real* impact of introducing MEPS for electric motors is the fact that by replacing an old motor for a new one, the opportunity is there to consider the whole 'electric motor driven system' (EMDS). This is where the largest saving opportunities lie.

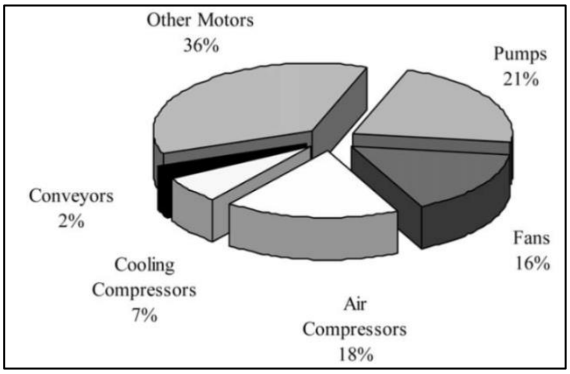
Figure 7: Motor System Definitions (EMSA, 2014b)



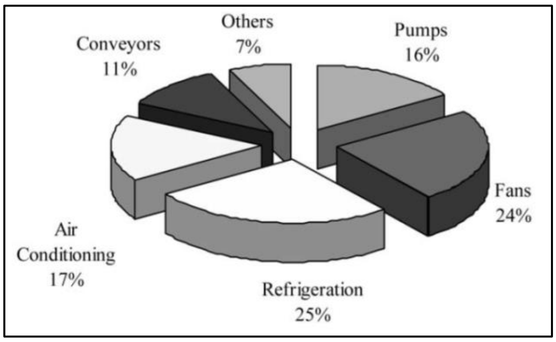
Many countries look at complete 'electric motor driven systems' (EMDS), which are defined in (Waide & Brunner, 2011) as:

4. **Electric motor**: a fully functioning electric motor run from the electric grid.
5. **Core motor system**: the electric motor and its driven piece of mechanical equipment (fan or pump wheel, compressor, etc.) plus the necessary interconnection (clutch, gear, transmission belt) and a variable-speed drive (VSD) system between the grid and the motor to control torque and speed.
6. **Total motor system**: the core motor system plus the eventual application of power (a water heating piping system, an air ventilation ducting system, a cooling system with its cold water network and the cooling tower, a compressed air pipe system and the storage tank, a conveyor belt installation, an elevator for people or goods, etc.), as well as electric equipment between the grid and the motor (such as uninterruptible power supply, transformers, power factor compensation, etc.).

The focus for pumps, fans and compressed air systems



In terms of 'the eventual application of power', pumps, fans and compressed air systems are the most common ones. In industry, these three applications are responsible for 62% of the total electricity consumption of electric motors (Almeida et al, 2003). Other motors include a large variety of loads mainly associated with materials processing (mills, grinders, laminators, extruders, mixers, agitators, centrifugations) and materials handling (conveyors, lifts, hoists, packaging).



Within the commercial sector, these three applications are responsible for an even higher electricity consumption: 82%. But this includes the ‘packed machines’, often the smaller size one-phase electric motors (Almeida et al, 2003).

Figure 8: Most common elements of an electric motor driven system (IETD, 2015)

As shown in **Figure 8**, the Industrial Efficiency Technology Database clearly gives the same message; first focus on pumps, fans and compressed air systems, and certainly include variable speed drives (IETD, 2015). When looking at electric motors only, most efficiency improvements (IE4) will result in about 5% electricity savings, as we have seen in the previous Section. But by considering the equipment around the motor, savings of 30% or higher can be reached.

So, in most cases, improving the efficiency of a motor system includes the following:

1. Use of energy efficient electric motors
2. Selecting the surrounding core components like pumps, fans, compressors, transmissions, variable speed drives, with the right type and size and high efficiency
3. Optimization of the design and operation of the complete system, which includes having the right people with the right skills

Policy tools targeting EE-EMDS
Looking at complete EMDS is more challenging than introducing mandatory MEPS only, but offers much larger benefits. To achieve this, successful best practices of other countries can be used to design a suitable policy program for Indonesia. A few reports give guidance on developing such policy packages, including (EMSA, 2011; EMSA, 2014b; UNIDO, 2011; Waide & Brunner, 2011). Besides introducing MEPS for electric motors, the following elements are often part of such a program, with a wide range of stakeholders involved:
1. Labelling
2. Voluntary agreements with industry
3. Energy management programs
4. Energy audit programs
5. Company motor policies
6. Financial incentives
7. Raising awareness and information provision

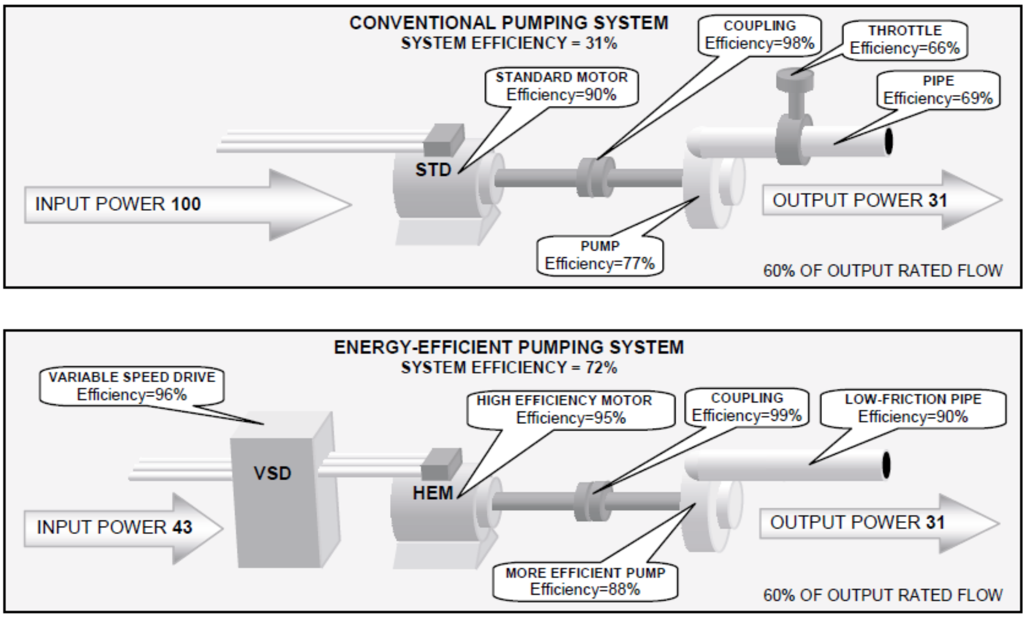
In Chapter 5 we will discuss international practices on this topic and how this translates to the situation in Indonesia.

2.7 Additional savings potential of EE-EMDS

As noted, the potential energy savings from motor systems will typically be larger than those achieved from individual motors only.

A practical example: optimizing a pumping system

Figure 9: Reviewing a whole pumping system (ECI, 2004)



In the upper part of **Figure 9**, an example is given of a possible old, or conventional water pumping system. It comprises out of a standard electric motor (IE1), a pump with a coupling in between, followed by a water piping system (UNIDO, 2011). In that system, we can find a throttle to adjust the water flow. The efficiencies mentioned in the drawing, are taken over in **Figure 10**.

The lower part of **Figure 9** shows the optimisation. Now, there is a high efficiency electric motor (IE4) and a more efficient pump, connected by a more efficient coupling system. The throttle has been replaced by a Variable Speed Drive (VSD) at the beginning of the system. The VSD is a very important part when optimizing flow-systems[4]. As well, the original piping system has been replaced by low-friction pipes. Of course, not all modifications will always be possible and/or be cost effective.

The new electric motor itself is probably smaller in terms of capacity, since older electric motors are often oversized. Engineers were afraid of overheating the motor when running at full power and (still) tend to purchase overcapacity equipment. Besides the fact that the present generation of electric motors are less vulnerable to overheating, a new motor for this pumping system can be smaller since the whole system needs less pumping-power after optimizing all components.

Figure 10: Savings when optimizing the pumping system described in **Figure 9**

	Motor efficiency	Coupling efficiency	Connected pump efficiency	Throttle versus VSD	Distrubution system efficiency	Total efficiency
Conventional:	90%	98%	77%	66%	69%	31%
Energy-efficient:	95%	99%	88%	96%	90%	72%
Savings:	5%	1%	11%	30%	21%	41%
Approach:	MEPS; labeling	Additonal approaches				

When only the electric pump would have been replaced, the electricity savings would have been around 5%. But now, by optimizing the whole system, a total saving of more than 40% has been reached. The largest contribution comes from the VSD, followed by the new piping system, the new pump, the effect of the high efficient electric motor and finally the coupling system.

Additional savings potential EE-EMDS used in this report

There are several factors that makes calculating the energy savings potential for EE-EMDS *in general* difficult:

- There are many different situations to be optimized. First of all there are the three main systems of **Figure 8**; pump-, compressed air- and fan systems. Within each category, there are several components that can be optimized, as show in **Figure 9** for pumping systems
- It is unknown *how many* systems, with all the just mentioned variations, there still are to be optimized in a country and what the present efficiency is, to form a business as usual (BAU) scenario
- Optimizing a system in real-life yields different efficiency improvements depending on the application and system design and many sources of literature do mention different efficiency improvements. For example, in (UNIDO, 2011) efficiency

4 In this YouTube movie it is shown how a VSD device works and why it saves so much energy (ABB, 2012b)

improvements are given, starting from 4% reduction of electricity demand after optimized a compressed air system, until 59% after the installation of 15 VSD's in a ventilation system in a textile plant.

Therefore the possible efficiency improvement that we can assume for a EE-EMDS scenario is unknown. This makes the difference between a BAU scenario and an EE-EMDS scenario difficult to calculate.

Exactly this challenge is recognized by the UNIDO report of (McKane & Hasanbeige, 2010). In this report, the authors try to come up with data that describes the savings potential of the three main EMDS's in the industrial sector in several countries, using assumptions for e.g. the present efficiency situation. Each EMDS has a number of energy savings measured appointed to it. As an example, see **Figure** 11; a pumping system comprises out of ten efficiency improvement measures.

Figure 11: % efficiency improvement of ten energy efficiency measures for pumping systems (McKane & Hasanbeige, 2010)

No.	Energy Efficiency Measure	Typical % Improvement in Energy Efficiency Over Current Pumping System Efficiency Practice			Expected Useful Life of Measure (Years)
		% Improvement over LOW eff. base case	% Improvement over MED eff. base case	% Improvement over HIGH eff. base case	
1.1	**Upgrade System Maintenance**				
1.1.1	Fix Leaks, damaged seals, and packing	3.5%	2.5%	1.0%	5
1.1.3	Remove scale from components such as heat exchangers and strainers	10.0%	5.0%	2.0%	4
1.1.3	Remove sediment/scale buildup from piping	12.0%	7.0%	3.0%	4
1.2	**Eliminate Unnecessary Uses**				
1.2.1	Use pressure switches to shut down unnecessary pumps	10.0%	5.0%	2.0%	10
1.2.2	Isolate flow paths to no-nessential or non-operating equipment	20.0%	10.0%	5.0%	15
1.3	**Matching Pump System Supply to Demand**				
1.3.1	Trim or change impeller to match output to requirements	20.0%	15.0%	10.0%	8
1.4	**Meet variable flow rate requirement w/o throttling or bypass****				
1.4.1	Install variable speed drive	25.0%	15.0%	10.0%	10
1.5	**Replace pump with more energy efficient type**	25.0%	15.0%	5.0%	20
1.6	**Replace motor with more energy efficient type**	5.0%	3.0%	1.0%	15
1.7	**Initiate predictive maintenance program**	12.0%	9.0%	3.0%	5

Each measure has been given a % efficiency improvement, depending on the present efficiencies situation of a country (Low, medium or high). One of the measures is the replacement of the electric motor itself (measure 1.6), resulting in 1%-5% efficiency improvement. Note that this coincides with finding in **Figure 9** and in findings for Indonesia in chapter 4.

From this report we can make the following general conclusions. If the Indonesian present efficiency situation can be compared with Vietnam and/or Thailand (present in the document[5]), the following electricity savings can be expected from the main three EE-EMDS's:

- Implementing cost effective measures: 45% (about 20%-point higher compared to US, Canada and EU)
- Implementing all measures: 52% (about 15%-point higher compared to US, Canada and EU)

From section 3.7 we know the electricity consumption of these sectors in Indonesia and the share that goes to electric motor driven systems. From Section 2.6 we know that pumps, fans and compressed air systems are responsible for 62% - 82% of the total electricity consumption in the industrial and commercial sector. We now know from this section that implementing measures can lead to 45% of cost-effective savings within the industrial sector. We don't know what this percentage is within the commercial sector, but since the commercial sector could have half of the yearly running hours compared to the industrial sector, we conservatively assume half of the savings potential (the yellow cell in the table below).

With this knowledge we can calculate the savings potential of EE-EMDS's, as shown in the last column of **Figure 12**. It turns out that in Indonesia, 25% of the electricity associated with motors can be saved by optimizing EMDS's in the industrial and commercial sector with cost effective measures. Note that the actual savings potential is likely to be even higher, as other EMDS's will be optimized besides pump, fans and air systems.

Figure 12: Calculating the savings potential of EE-EMDS systems

	Electricity consumption GWh 2025	Electricity consumption EMDS's GWh 2025	% that goes to pumps, fans, air systems	Electricity consumption pumps, fans, air systems GWh 2025	Savings-% energy efficienct pumps, fans, air systems	Electricity savings potential pumps, fans, air systems GWh 2025	As a % of electricity consumption of EMDS's GWh 2025
From:	Section 3.7	Section 3.7	Section 2.6	calculated	Section 2.7	calculated	calculated
Total Industrial sector	143,104	107,328	62%	66,544	45%	29,945	28%
Commercial sector	128,056	48,661	82%	39,902	23%	8,978	18%
Total	271,160	155,990	68%	106,446	37%	38,923	25%

5 **Figure 12** gives the average of efficiency improvements in the 'LOW base case' for Vietnam and the 'MED base case' for Thailand.

The term ‘cost effective’ in (McKane & Hasanbeige, 2010) is different from what we will use in this report. In chapter 3 we will use a 3 years simple pay-back period as being ‘cost effective’. This is more applicable to the investment practices of firms. In (McKane & Hasanbeige, 2010) ‘cost effective’ means it will pay itself back within the ‘expected useful lifetime’ as mentioned in **Figure 12**. From these measures, only the last three will not pay themselves back in all situations and need to be evaluated from case to case. One of these is the replacement of a motor by a more efficient one. Obviously when a MEPS is introduced on EE electric motors, there is no need to evaluate the cost-effectiveness of this measure[6].

In this report we will use a more conservative savings potential for EMDS’s. We take into account the fact that we only accept a three years pay-back time for non-compulsory measures. We lower the savings potential to a more conservative figure of 20%. This by definition includes replacing the electric motor with a more efficient type. Since we consider this as a compulsory policy measure that stands on its own through the introduction of MEPS, we deduct a further 5%-point. This finally means that if it is decided that the whole electric motor driven system will become part of the policy approach, *on top of introducing MEPS,* the savings potential will increase with an additional 15%-point.

6 Similar, a label for energy efficient pumps could be introduced, which will target this measure and could lead to savings up-to 25% according to **Figure** 11.

3

Assessing the industrial and commercial sector

3.1 Key messages

Electricity consumption of electric motors and related GHG emissions

- Without any intervention, the business as usual (BAU) scenario shows that electricity consumption of large and medium motors will triple by 2035 in Indonesia, as will CO_2 emissions associated with this electricity use.
- Significant savings are possible by replacing older inefficient motors by examples that perform better and by improving the general efficiency of the complete system that is driven by the electric motor. These changes are in many cases profitable and pay themselves back within 3 years' time.

Efficiency and savings potential

- Introducing minimum energy performance standards (MEPS) at the first level of IE1 in Indonesia will give less than 1% energy savings compared to BAU. This is because the efficiency improvements are small between different 'IE' levels for larger motors, and because IE1 motors dominate the present market share in the country. If Indonesia improves its MEPS level over time to IE4, electricity savings would be 5% compared to BAU.
- As noted in section 2.7, it is estimated that the potential energy savings that could be achieved by looking at entire motor driven systems is on average 4 times higher than the figure for MEPS only; i.e. up to 20% savings.

Pay-back period energy efficient motors

- Over the lifetime of a motor, the purchase price only takes a few percentage of the total costs (typically less than 5%), in many cases it is profitable to replace an old motor with a payback period of only 3 years. The payback period shortens, when governmental subsidies over electricity decreases. Even changing an older motor which has not come yet to the end of its technical lifetime, is often profitable. An interesting observation is that in many cases, changing the old motor for an IE2, IE3 or even an IE4 motor instead of an IE1, shortens the pay-back period further.

Financial benefits sector and government

- Assuming that the present motor stock will be replaced by the year 2035, implementing the MEPS at level IE1 will save the commercial and industrial sector on average yearly 774 bln IDR or 60 mln USD (saved electricity consumption) and the government 461 bln IDR or 36 mln USD (avoided subsidies), Implementing MEPS at level IE4 would increase these savings with a factor 7.
- The EMDS policy approach would quadruple the effects of a IE4 MEPS-only program.

Needed investment and installation workforce

- To replace the present stock of electric motors under a MEPS programme, will need up to 2035 an average yearly direct investment of 2,500 to 3000 bln IDR or 190 to 240 mln USD, depending on IE-level.
- We assume that only electric motors larger then 11kW will need external installing engineers. Since this counts only for 10% of the total stock that should be replaced, total costs for installation and total needed external workforce are relatively small. Costs for installation will add only 70 bln IND or 5 mln USD (2.5%) and needs around 325 external engineers with a full-time job.
- When a EMDS policy approach is added, the needed direct investment will increase with a factor 8; this still represents cost effective investments, with a simple payback time of maximum three years.
- We assume that as well systems driven by electric motors smaller than 11kW will need external engineer. Since these additional measures are as well more complex and time consuming to implement, the total labour costs and needed man-years will increase with a factor 18.

3.2 Chapter introduction

This Chapter looks at the energy consumption of current electric motors in Indonesia, and the related savings potential and other benefits when systems would be improved. The chapter is broken down in the following way:

- Section 3.3 first describes the market share of electric motors in Indonesia, by IE-class and by motor size.
- Section 0 calculates the electricity savings when the efficiency of the present motor stock would be increased under a MEPS programme
- Section 3.5 compares the purchase price versus life-time costs for electric motors
- Section 3.6 estimates payback periods of energy efficient motors for Indonesia, depending on IE-class.
- Section 3.7 describes the present and future electricity consumption and related CO_2 emissions in a business as usual (BAU) scenario for Indonesia.
- Section 3.8 gives projections of the electricity consumption up to 2035 when MEPS at a certain IE-level are introduced and compares this with both the BAU scenario and a more ambitious scenario that takes into account the entire electric motor driven system (EMDS)
- Section 3.9 estimates cumulative savings until 2035 and related financial benefits for the sectors and government.
- Section 3.10 estimates the needed investment and installation workforce of introducing MEPS regulations.

- Section 3.11 complements the findings of the previous section when a MEPS programme would be extended with a focus on energy efficient electric motor driven systems (EE-EMDS's)

3.3 Market share of electric motors

When calculating the effect of a chosen MEPS for EI1, IE2, IE3 or IE4, the big challenge for Indonesia is to determine the present market share of these IE-classes.

Present market share by IE-class
There is not much data available on the present Indonesian motor stock. Appendix A reflects our thinking process that has led to our assumption of the present market share by IE-class, as presented in **Table 1**.

Table 1: Present market share electric motors Indonesia by IE-class

IE class	% market share (units until 0.75 kW)	% market share (units between 0.75 and 45 kW)	% market share (units above 45 kW)	% market share (all units)
IE4	0%	0.4%	0.8%	0.3%
IE3	0%	2%	5%	2%
IE2	0%	5%	10%	3%
IE1	50%	59%	68%	56%
IE0	50%	34%	17%	39%
Total	100%	100%	100%	100%

Note that from interviews we know that the larger electric motors within international industries, as the oil- and gas-industry, often come from countries as Germany, Italy and the USA, and are by company regulation high efficient. We even have seen a few IE4 electric motors.

Market share by motor size and related electricity demand, 2014 bottom-up approach
In a study of (PT Solvindo & ICA, 2013) import data for electric motors from the Directorate General of Customs and Excise has been collected. The study gives a forecast for the motor import figures of 2014. For several motor capacity ranges, it gives the predicted numbers of motors imported in 2014. We have used this data to make an estimate of the Indonesian motor market share by motor size and the related electricity consumption. More details on the bottom-up approach is given in Appendix B. The results of this exercise are summarized in the table below, together with a comparison for world-figures (taken from **Figure 1**). The naming convention based on motor size follows that was introduced in Chapter 2

- Small size motors: less than 0.75 kW
- Medium size motors: from 0.75 kW up to 375 kW
- Large size motors: above 375 kW, up to e.g. 100.000 kW

As explained in Chapter 2, this project focuses mainly on the medium size motors, followed by the large size motors. This table tells us that the small motors (<0.75 kWh), that need a different approach and are comparatively more important than in other countries. But at the same time, this counts for the medium size motors (0.75 kW up to 375 kW) as well. In contrast, the large size electric motors have become less dominant than global averages[7].

Table 2 World and Indonesian electric motor market share by size

	small size motors	medium size motors	large size motors	total medium & large motors	total motors
World: total running stock 2009 mln pieces	2,000	230	0.6	231	2,231
Indonesia: total running stock 2014 mln pieces	40	3.1	0.001	3.1	43
World electricity demand 2009 (TWh/yr)	632	4,676	1,611	6,287	6,919
Indonesia electricity demand 2014 (GWh/yr)	12,549	66,136	10,830	76,966	89,515
The above numbers turned into a percentage					
World: % of total running stock	90%	10%	0.03%	10%	100%
Indonesia: % of total running stock	93%	7%	0.002%	7%	100%
World: % of total electricity demand	9%	68%	23%	91%	100%
Indonesia: % of total electricity demand	14%	74%	12%	86%	100%

Electricity demand medium- and large size electric motors, 2014 top-down approach
In section 0 we will use several sources to construct a business as usual scenario for the electricity demand of medium and large size electric motors. For this, we will use a top-down approach. The outcome for the year 2014 has been added to **Table 3**, where we compare this with the bottom-up approach of the previous table. We can conclude that the top-down and bottom-up results do more or less coincide for the year 2014. This gives us more confidence around the reliability of calculated savings potential in next sections.

Table 3: Electricity consumption medium- and large size electric motors, comparing bottom-up and top-down approach

Industrial plus commercial sector	million BOE usage 2014	TWh usage 2014	Total electric motor stock; medium and large size (pieces)	Average efficiency
Bottom-up approach (2014): import data Solvindo	47	77	3,100,000	88%
Top-down approach (2014): Indonesian statistics	46	75		
Compare with world (2006): according to IEA (2011)	3,624	5,900	230,600,000	87% - 93%
Indonesia 2014 as % from world 2006	1.3%	1.3%	1.3%	

7 Note that this coincides with findings in (McKane & Hasanbeige, 2010) where it is shown in table 4 that in countries as Vietnam and Thailand the share of energy use by systems larger than 745 kW is about half compared to the same share of countries as the US, Canada and the EU. This effect is stronger for fan and compressed air, and less for pumping systems.

3.4 Savings potential of MEPS by IE-class

With the present market share of electric motors by IE-classes and related efficiencies, we can calculate the energy savings effect of the introduction of MEPS. **Table 4** gives the results. The results are for medium-, and large size electric motors. Imagine a MEPS on IE1 will be introduced. When all present IE0 motors (present market share 39%) are replaced by IE1 motors, the electricity savings for electric motors will be 0,7% compared to the present total electricity consumption. Similar analogies can be followed for MEPS on IE2, IE3 and IE4. The maximum energy savings that can be reached by introducing MEPS for IE4, will be 5.1%.

Table 4: Energy savings electric motors of MEPS IE-targets

		Market share and savings for chosen MEPS IE-class				
Motor efficiency class	**International coding**	**Present share**	**MEPS on IE1**	**MEPS on IE2**	**MEPS on IE3**	**MEPS on IE4**
Super premium	IE4	0.3%	0.3%	0.3%	0.3%	100%
Premium	IE3	2%	2%	2%	100%	0%
High	IE2	3%	3%	98%	0%	0%
Standard	IE1	56%	95%	0%	0%	0%
Below Standard	IE0	39%	0%	0%	0%	0%
	Total share:	**100%**	**100%**	**100%**	**100%**	**100%**
	% savings MEPS IE-target	**0%**	**0.7%**	**2.9%**	**4.4%**	**5.1%**

3.5 Purchase price over life-time by sector and IE-class

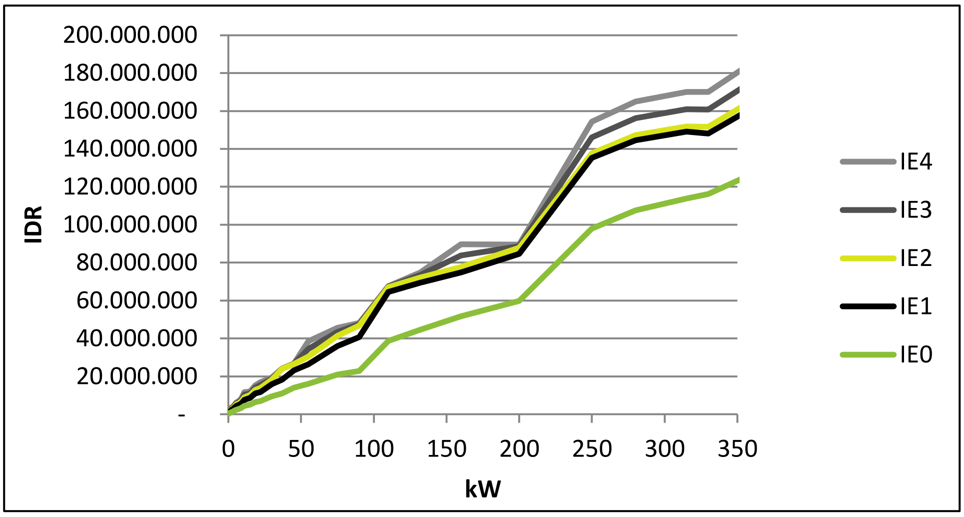
In section 2.5 we have seen that sources mention that the purchase price of an electric motor often is very small compared to the total life-cycle costs. We wanted to check this for Indonesia. We visited Glodok[8] and collected information about the catalogue purchase price of the cheapest 4 pole electric motors, assuming that these would be IE0.

To have a comparison with IE1, IE2 and IE3 prices, we have used the price catalogue of one prominent international dealer of electric motors[9]. In Appendix D the purchase price that we use for further analysis is given. The data is represented by **Figure 13**.

8 Glodok is a part of Jakarta, Indonesia. Nowadays the area is known as one of the biggest centres for electronics in the country.

9 We did compare the prices of a few examples by motor size with other international dealers and concluded that they all fall within the same price-range. According to some vendors, to the catalogue price, about 20%-50% will be added when contacted by a company. But at the same time, the representative of that company will

Figure 13: Purchase price electric motor by size and IE-class



The first conclusion is that within the lower capacity ranges, the IE1 electric motor is double the price of the cheapest electric motors, in this report defined as IE0. This is difficult to see in this figure. When the size of the motor increases, the difference is less. At around 132 kW, an IE1 electric motor is 50% more expensive compared to a IE0 electric motor. As we know already, the difference in efficiency decreases at the same time as well. Level IE2 is for the lower ranges 25% more expensive compared to IE1. For the highest capacities, this drops to 2%.

In addition to the catalogue purchase price, there are costs for installation of the electric motor. This estimation has been made by an Indonesian company trading in European electric motors and are mentioned in Appendix D. These costs we keep the same, regardless the IE-class.

From (PT PLN Persero, 2014) we took the following average electricity prices[10]:

- Industrial sector: 796 IDR/kWh
- Commercial sector: 1,117 IDR/kWh
- Average for Indonesia: 818 IDR/kWh, with a government subsidy of 540 IDR/kWh

With this information, combined with the efficiencies for IE0 motors, we can construct **Figure 14**. This figure shows the relative purchase costs, depending on yearly running hours for a low quality 1.1 kW IE0 electric motors found in Glodok. For the technical life time, we took 12 years. This is probably less than the real operating time, which could be 20 years, but is part of a good motor policy. The graph shows the result for the industry, the commercial sector and for a situation without subsidized electricity prices. **Figure 15** shows the same for a IE1 motor.

negotiate a lower price than initially offered by the vendor. With this reason, we stick to the catalogue price for further analysis.

10 Note that the subsidy and therefore real electricity price for a sector depends on several factors, including voltage-level and the geographical location. The lowest industrial electricity price we have found was as low as 739 IDR/kWh; the highest 1379 IDR/kWh. For the commercial sector we have found 831 IDR/kWh until 1379 IDR/kWh (PT PLN Persero, 2014). The average prices used here can be considered as an average for Java Island.

Figure 14: Relative purchase price over life-time, related to total life cycle costs, IE0

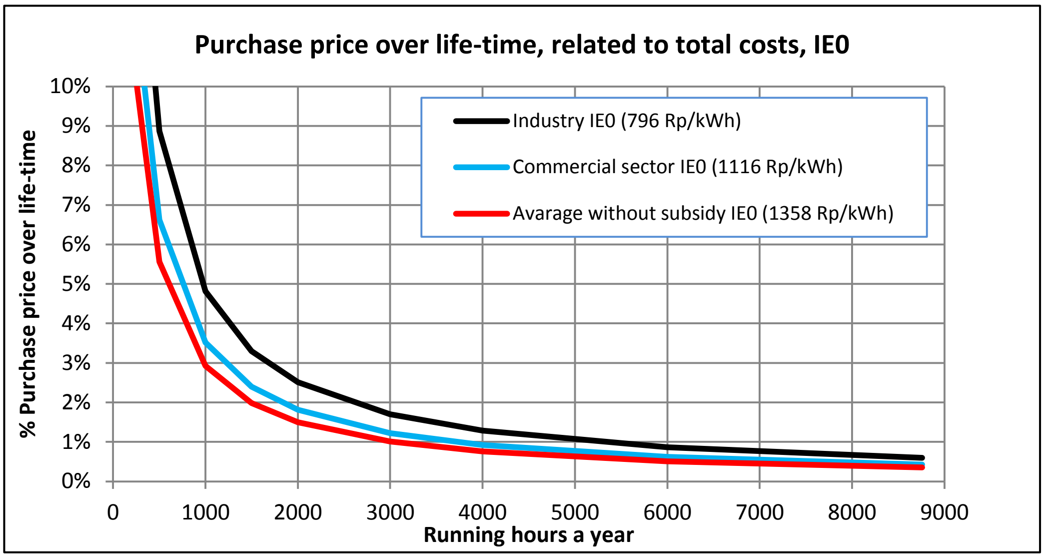
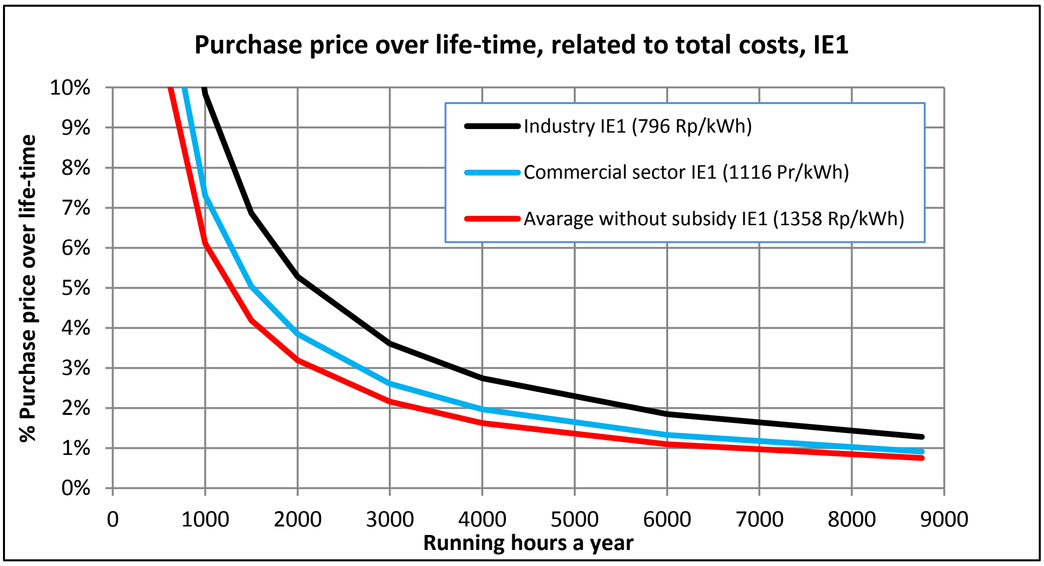


Figure 15:Relative purchase price over life time, related to total life cycle costs, IE1



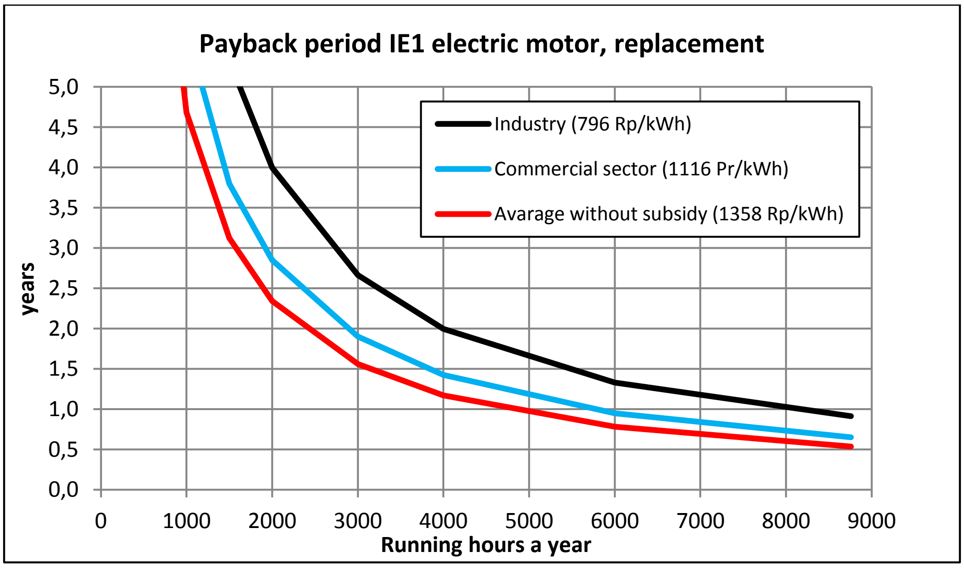
The figures tell us indeed that the fraction of lifetime costs represented by the purchase price is relatively small, but, obviously, highly dependent on running hours per year and chosen equipment lifetime. Even with subsidized electricity prices, the relative purchase price over lifetime lies for the IE0 motor around 1% to 1.5%, at 4000 hours a year. For the IE1 motor this is in between 1.5% and 3%. This more or less coincides with finding in other countries around the globe. Due to the subsidized electricity price, the percentage is somewhat higher for the industry, but is still small compared to the total life-cycle electricity costs. At lower running hours a year, this percentage increases.

3.6 Pay-back period by IE-class and sector

End-of-life replacement

These figures can be combined and turned into **Figure 16**, which shows the simple payback period in years, when there is a need to replace an old existing IE0 motor by an IE1 motor, instead of choosing again the cheaper IE0 motor. Now, only the *additional* costs of the IE1 compared to the IE0 have been taken into account.

Figure 16: Simple payback period replacement, IE1 instead of IE0 electric motor



The acceptable payback period might be different from one (industrial) sectors to another. But the government could set this as well, e.g. depending on yearly electricity consumption. As a comparison, in the Netherlands, each company that consumes minimum 50,000 kWh and/or 25,000 m3 gas a year, is obliged to implement all energy saving measures with a payback period of maximum 5 years (Infomil, 2015). For being able to draw conclusions out of this figure, let's assume for now that 3 years is an acceptable payback period for most companies in Indonesia. Then, all industrial electric motors of 1.1 kW that need to be changed, should be changed by an IE1 motor, when the running hours a year exceeds 2800. For the commercial sector this lies a bit lower, around 2000 hours a year. When subsidies would be removed, this would be valid above 1500 hours a year.

Note that 2800 hours a year is often very small for the industry. An industrial sector with a 24 hours production line, has 8769 running hours a year. In a situation like this, as you can see from the figure, the investment would be paid back after 1 year.

Mid-life replacement, or 'new placement'

But imagine the existing running electric motor does not necessarily need to be changed; i.e. it is not near or at the end of its operational life. In Appendix E we have calculated this the same way as the previous Section. There we conclude that the acceptable payback period of three years is now reached around double the amount of running hours a year:

- Industrial sector: 5500 hours a year

- commercial sector: 3800 hours a year
- when subsidies would be removed: 3000 hours a year

This is simply due to the fact that the IE1 motor is about double the price of a IE0 motor.

Replacing IE0 by an high efficiency IE2 motor

This way, we can analyse an almost endless number of different situations. Although this is not the purpose of this Section, one specific observation is most interesting to share. In Appendix F we have calculated that it is financially more attractive to replace an IE0 by an IE2, instead of by an IE1 motor. It is still more attractive to replace an IE0 motor, by an IE3 or IE4 class motor, instead of by an IE1 motor. From this perspective, there is no reason *not* to set the intended MEPS directly on IE2 instead of IE1.

This shows that understanding costs and savings is important when setting regulation. Similar types of calculations can easily be done for other situations, with other capacities, electricity prices, running hours a year and IE-classes of motors. This should automatically become part of energy management strategies, energy audits and motor policies, as will be discussed in chapter 5.

Analyse the pay-back period yourself

In order to analyse other situations, we have constructed a calculation tool in Excel. This tool gives you for certain input-data which change in IE-class has the lowest pay-back period. The results are delivered in the form of a matrix with horizontal the running hours, and vertical the capacity of the electric motor. The below figure shows a part of the table.

End of life-time replacement; natural moment

kW - run hours	500	1000	1500	2000	2500	3000	3500	4000	5000
0,37	IE0	IE0	IE0	IE3	IE4	IE4	IE4	IE4	IE4
0,55	IE0	IE0	IE0	IE0	IE4	IE4	IE4	IE4	IE4
0,75	IE0	IE0	IE0	IE3	IE4	IE4	IE4	IE4	IE4
1,1	IE0	IE0	IE0	IE3	IE4	IE4	IE4	IE4	IE4
1,5	IE0	IE0	IE0	IE3	IE4	IE4	IE4	IE4	IE4
2,2	IE0	IE0	IE0	IE0	IE4	IE4	IE4	IE4	IE4
3,0	IE0	IE0	IE0	IE0	IE4	IE4	IE4	IE4	IE4
3,7	IE0	IE0	IE0	IE0	IE4	IE4	IE4	IE4	IE4
4,0	IE0	IE0	IE0	IE0	IE4	IE4	IE4	IE4	IE4
5,5	IE0	IE0	IE0	IE0	IE4	IE4	IE4	IE4	IE4
7,5	IE0	IE0	IE0	IE0	IE4	IE4	IE4	IE4	IE4
9,0	IE0	IE0	IE0	IE0	IE4	IE4	IE4	IE4	IE4
11,0	IE0	IE0	IE0	IE0	IE0	IE3	IE4	IE4	IE4

It shows you the results as well for a mid-term replacement and gives the pay-back period in years. As input data one can change:

1. Electricity price
2. IE-class present electric motor that needs, or will be replaced
3. Maximum accepted pay-back period by purchaser
4. Purchase costs by electric motor capacity and IE-class
5. Installation costs by electric motor capacity and IE-class
6. Efficiency by electric motor capacity and IE-class

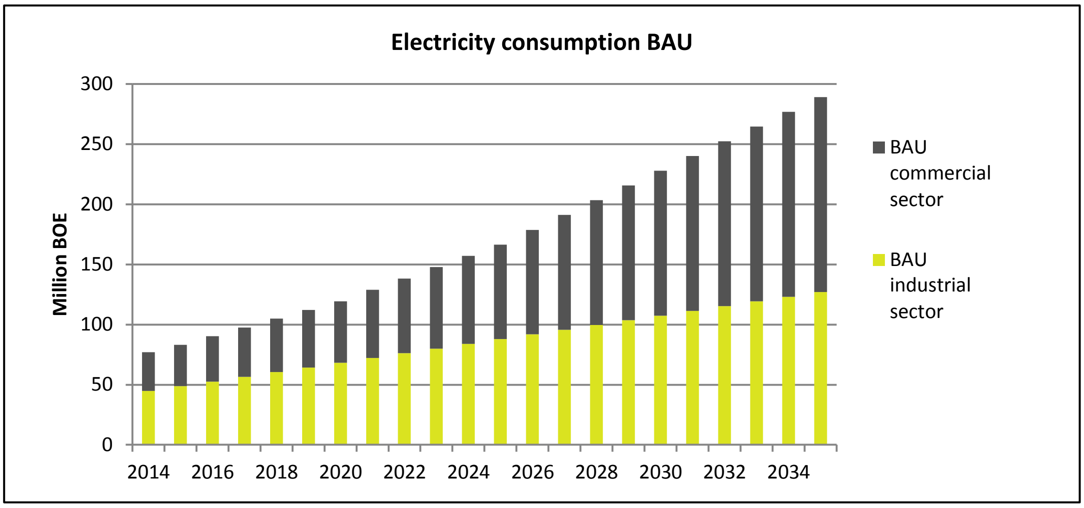
This Excel tool, named ‘Pay-back Period EE Electric Motors’ can be found on our project website: www.ecn.nl/projects/ee-motors-indonesia.

3.7 Business as usual scenario towards 2035

Electricity consumption industrial and commercial sector

By combining several sources of information[11] we have estimate the electricity consumption for the business as usual scenario for the commercial- and industrial sector of Indonesia. **Figure 17** shows the final result. The figure gives the development of electricity consumption for these two sector until 2035.

Figure 17: Electricity consumption commercial and industrial sector, business as usual

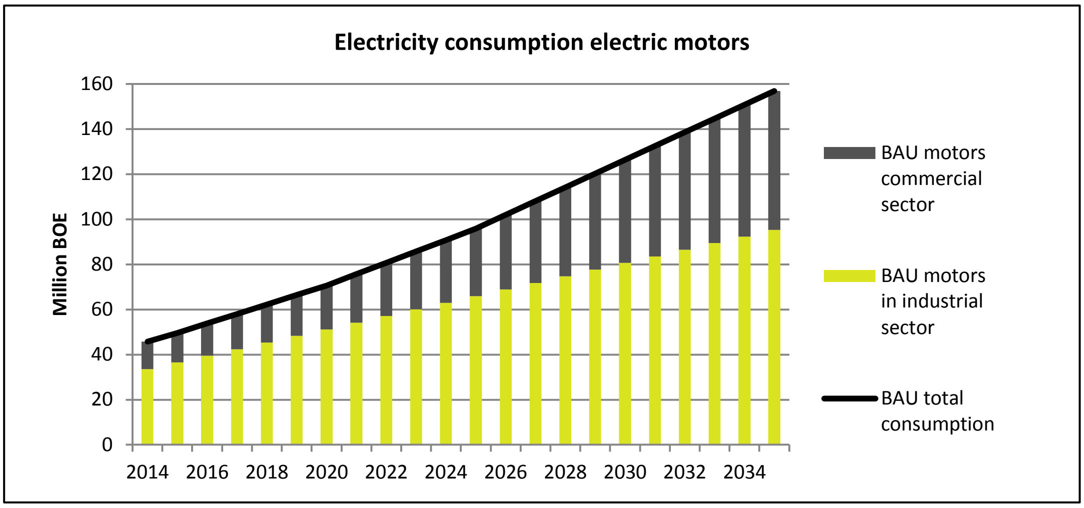


Electricity consumption electric motors only

From several sources, we estimate that 38% of the total electricity consumption of the commercial sector goes to electric motors. For the industrial sector this is 75%. The previous figure can be transferred into **Figure 18**, only giving the electricity consumption of electric motors in these sector. This consumption will be mainly related to middle-, and large size electric motors. This is our starting point for calculations of energy saving, later in the chapter. Note that the BAU scenario in reality should take into account the fact that some ‘old’ electric motors will be changed to more efficient ones as well without introducing MEPS. This means that in reality BAU and calculated savings will be slightly lower in 2035 then these and next figures predict; however the effect of this is expected to be low.

11 (Ambarita, 2014a; Ambarita, 2014b; APEC, 2012; Economy, 2014; IEE, 2011; Permana et al, 2012; UNEP, 2014). Note that the consumption until 2014 (not shown in this figure) coincide with Indonesia energy statistics (BPS, 2015).

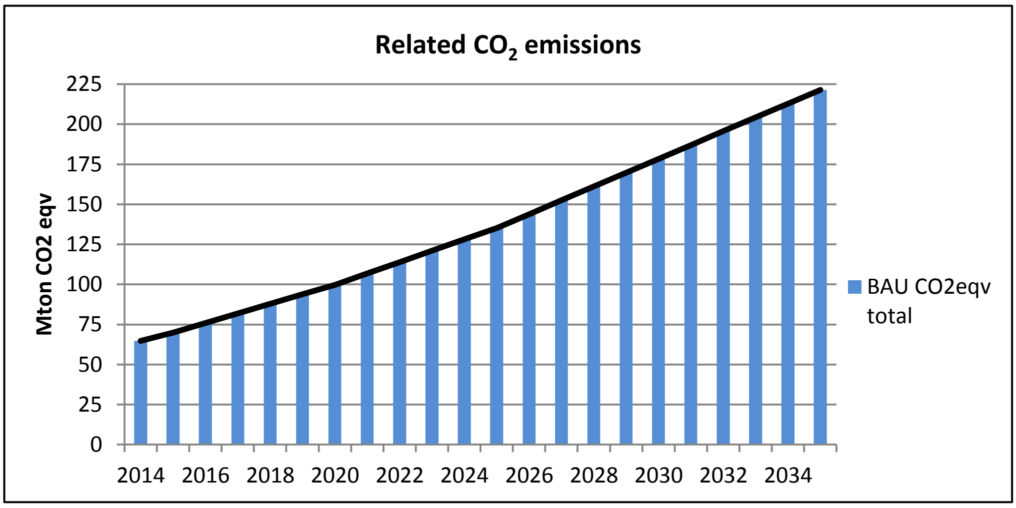
Figure 18: BAU electricity consumption of electric motors



Related CO_2 emissions

This figure can be transferred into **Figure 19**, giving the related yearly CO_2 emissions in Mton CO_2 for this BAU scenario. This represents the CO_2 emissions for the needed electricity generation by PLN. For this conversion, CO_2 emission data released by PLN has been used. The average number for Indonesia of the year 2015 has been applied, which is 0.867 ton CO_2eqv/MWh. Note that this will not be a constant factor over time, and will change slightly with a different fuel mix and a changing share of renewable electricity production.

Figure 19: BAU related $C0_2$ emission



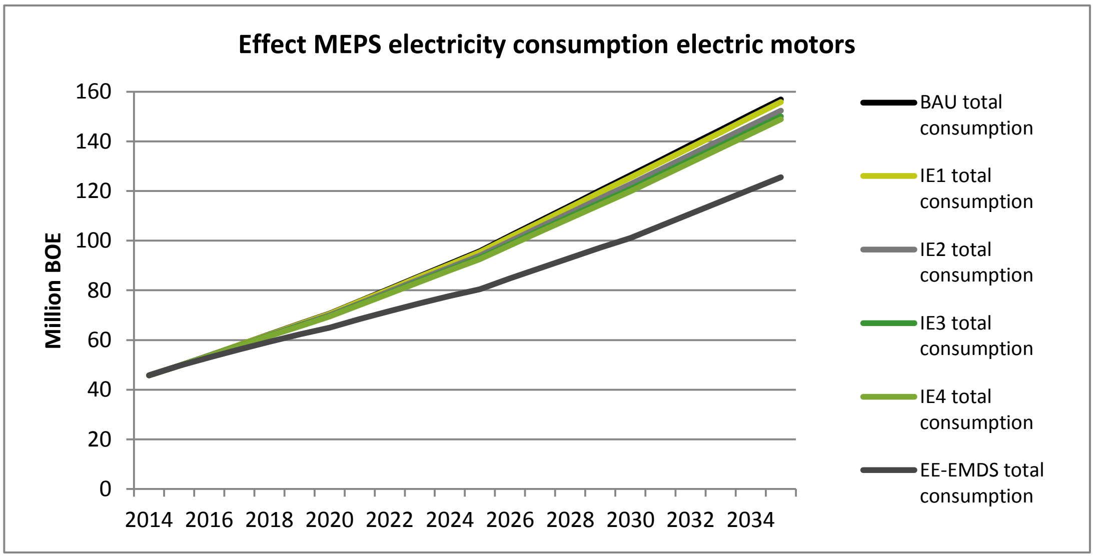
3.8 Savings potential MEPS and EE-EMDS by 2035

Savings potential of MEPS by IE-class

The Section 2.5 started with the remark 'Savings will not be reached quickly', referring to the technical or real life-time of electric motors. With the information and conclusions that came after this remark, we now assume that the job could be done within 15 years' time. This assumption follows mainly end-of-life replacement strategies and takes into account the life time expectancy of electric motors.

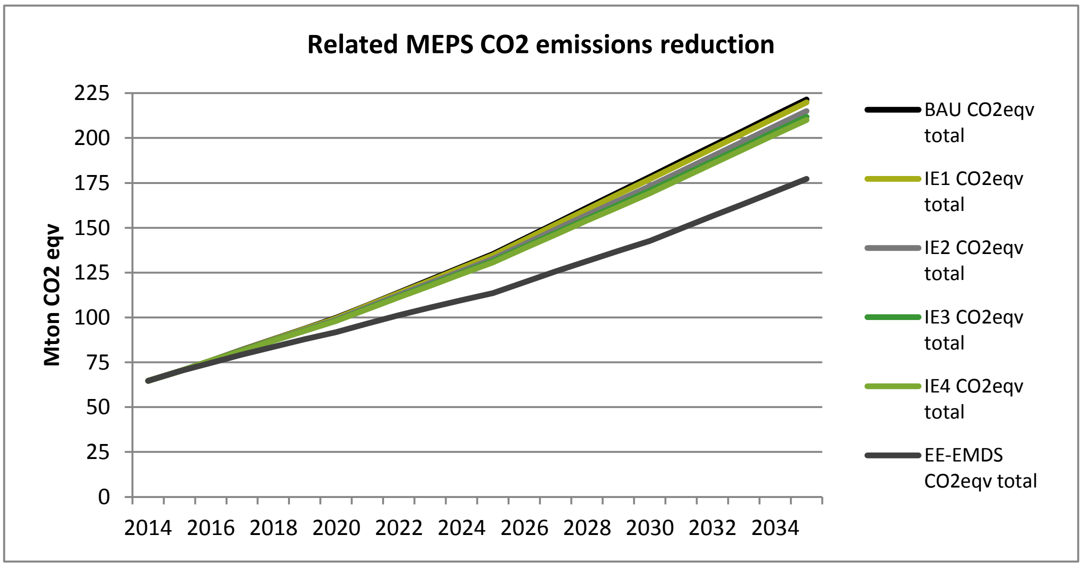
In **Figure 20** the effect of a chosen MEPS IE-class is given. The figure shows the development of the electricity consumption until 2035 of the electric motors running in the industrial and commercial sector. The BAU scenario of **Figure 18** is the upper black line, followed by scenario's representing MEPS at IE class 1, 2, 3 and 4. The lowest line with the abbreviation 'EE-EMDS' stands for 'Energy Efficient - Electric Motor Driven Systems', as described in Section 2.6. and 2.7.

Figure 20: MEPS IE-classes; development of electricity consumption



By introducing MEPS at a certain IE-level, electricity consumption gradually drops over time. In 2030, after 15 years from now, the energy consumption for IE4 is 5.1% lower, compared to BAU (see **Table 4** in Section 0). From that year onwards, the difference between BAU and IE4 will remain at that percentage, since all electric motors have been replaced. **Figure 21** gives the related CO2 emission, compare this with **Figure 19**.

Figure 21: MEPS IE-classes; related CO2 emissions



Imagine that Indonesia would start with a MEPS at IE1 in 2015, and has reached a MEPS at IE4 before 2035. The drop in electricity consumption would then follow a pattern, somewhere in between the IE-lines of **Figure 20**, depending on how fast the shifts to the next IE-levels are made.

Savings potential of EE-EMDS

Going back to **Figure 20**, the savings potential for optimizing the whole system, on top of introducing IE4, is represented by the lowest line 'EE-EMDS total consumption'. Optimizing the whole system off course should not wait for IE4, but should be done the moment any new electric motor has been purchased. In section 2.7 we have used previous studies to calculate a conservative additional 15%-point savings potential, on top of the 5% related to introducing a future MEPS at IE4.

Cumulative savings towards 2035

A different way to present **Figure 20** and **Figure 21**, is by giving a cumulative effect over time, as has been done in Appendix G.

3.9 Financial benefits to the sector and government

The electricity savings can be transferred into financial benefits for the commercial and industrial sectors simply by multiplying saved electricity by electricity price. For this, we have taken an weighted average electricity price of 907 Rp/kWh. The same way, we calculate the government avoided subsidies (540 Rp/kWh (PT PLN Persero, 2014)). These numbers are not likely to remain the same until 2035, but in the absence of better information it is assumed that today's situation remains unchanged in order to illustrate financial impacts.

Table 5 is an extension of **Table 4** of Section 0. First of all, the EMDS scenario has been added in the last column. Then, in the bottom part of the table, first cumulative effects in 2035 are given for electricity savings, avoided CO2 emissions, financial savings of the electricity bill for the industrial and commercial sectors and avoided governmental subsidies on electricity. In the last part of the table, this cumulative effect is tuned into an average yearly effect by simply dividing the previous number by 20 years. The EMDS policy approach would quadruple the effects of a MEPS-only program. See Appendix H for the same table in USD.

Conclusions:

- Implementing the MEPS at level IE1 will until 2035 result in an average yearly electricity saving of 0.9 TWh. This relates to 0.7 avoided Mton of CO2. This will save the commercial and industrial sector on average 774 bln IDR (saved electricity consumption) and the government 461 bln IDR (avoided subsidies).
- If from the first moment MEPS would be at level IE4 and the system approach would be part of the implemented policy, these numbers can be multiplied by a factor 30.
- Although we have seen that setting MEPS at a higher IE-level often results in a shorter pay-back period, it is probably not realistic to expect that MEPS would start at a level beyond IE1. Still, taking into account the system approach as explained in section 2.7, this will increase the savings potential with an additional 15%-point *on top of introducing MEPS*.

Table 5: Cumulative and yearly average effects of MEPS IE-targets and EMDS

		Market share and savings for chosen MEPS IE-class					
Motor efficiency class	**International coding**	**Present share**	**MEPS on IE1**	**MEPS on IE2**	**MEPS on IE3**	**MEPS on IE4**	**MEPS on IE4 and EE-EMDS**
Super premium	IE4	0.3%	0.3%	0.3%	0.3%	100%	100%
Premium	IE3	2%	2%	2%	100%	0%	0%
High	IE2	3%	3%	98%	0%	0%	0%
Standard	IE1	56%	95%	0%	0%	0%	0%
Below Standard	IE0	39%	0%	0%	0%	0%	0%
	Total share:	100%	100%	100%	100%	100%	100%
	% sector savings MEPS IE-target	0%	0.7%	2.9%	4.4%	5.1%	20%
	Cumulative results 2015-2035 (20 years)						
	Cumulative savings sector 2035 (mln BOE)	-	10	44	66	78	321
	Cumulative savings sector 2035 (TWh)	-	17	71	108	126	523
	Cumulative avoided CO2 emissions sector 2035 (Mton)	-	15	62	93	110	454
	Cumulative savings sector 2035 electricity bln IDR	-	15,483	64,575	97,663	114,672	474,556
	Cumulative savings governmental subsidies 2035 bln IDR	-	9,215	38,434	58,127	68,251	282,447
	Average results a year 2015-2035						
	Average yearly savings sector untill (mln BOE)	-	0.5	2.2	3.3	3.9	16.1
	Average yearly savings sector (TWh)	-	0.9	3.6	5.4	6.3	26.2
	Average yearly avoided CO2 emissions sector (Mton)	-	0.7	3.1	4.7	5.5	22.7
	Average yearly savings sector 2035 electricity bln IDR	-	774	3,229	4,883	5,734	23,728
	Average yearly savings governmental subsidies bln IDR	-	461	1,922	2,906	3,413	14,122

3.10 MEPS: needed investment and installation workforce

By combining data, we can estimate the total investment costs and workforce needed, to replace the present stock under a MEPS programme. This analyses has been done in Appendix I. **Table 6** gives the average yearly effect between 2014 and 2035.

Table 6: Yearly replacement costs bln IDR and needed man-years for a certain MEPS programme

Average yearly 2014-2035	IE1	IE2	IE3	IE4	Total	Total installation costs bln (bln IDR)	Needed man-years installation
IE1 MEPS replacement bln IDR	2,177.58	199.32	97.85	17	2,492	71	326
IE2 MEPS replacement bln IDR	-	2,679	97.85	17	2,794	71	326
IE3 MEPS replacement bln IDR	-	-	2,981	17	2,998	71	326
IE4 MEPS replacement bln IDR	-	-	-	3,207	3,207	71	326

Conclusion: to replace the present stock of electric motors under a MEPS programme, will need an average yearly *direct* investment of 2.500 to 3000 bln IDR. Costs for installation will add only 70 bln IND (2.5%) and needs around 325 people with a full-time job.

Only 325 man-years feels quite small and needs some additional insights:

- We assume that only motors with a capacity starting from 11kW will need external labour; motors with a smaller capacity will be replaced by the purchasing companies themselves (see Appendix D). Obviously, this is internally needed labour as well, but we decided not to include this. This implicates that only 10% of the middle and large size motors stock will need external labour capacity.
- As explained in the text, it should be noted that this is the average yearly number until 2035; to replace the total motor stock (>11kW) that will be present in 2035 will need 6,500 man-years (see Appendix I).
- The needed workforce relates to installing engineers only; obviously the workforce will grow with employees busy with e.g. trading and delivering. We see this as an indirect effect and have not estimated this additional needed indirect workforce.
- Good to know already at this stage: in the next section, when calculating the needed workforce for optimizing electric-motor driven systems, we take a different approach. Now, we expect that installing an optimized system, driven by electric motors smaller then 11kW, will need external engineers as well. The optimizing auditing process prior to installation will be done by an external expert, followed by installing-engineers. But again, only the installing-engineers have been counted as the direct labour-effect.

Local manufacturing of medium size electric motors?

There are as well *indirect* effects, as needed man-years for electric motor production.

At the moment, only Teco is manufacturing a limited numbers of medium size electric motors a year. This means almost all motors will have to be imported; a large part of the indirect effect therefore will take place abroad.

An interesting thought is Indonesia as a motor producing country. Own production would have major positive effects:

- a boast to the economy,
- export revenues,
- less low-quality electric motors being imported (and/or smuggled) into the country,
- International recognition and cooperation and, last but not least,
- an enormous boost for local job creation and national investments.

In the past Tatung and ABB had local production of medium size motors. There are several factors for ending own production capacities as discussed in (JICA & PT.EMI, 2009). Interesting to realize is the large Indonesian manufacturing industry for *small* electric motors. According to the Ministry of Industry in 2011 there were 12 manufacturing companies for electric motors. They together have a capacity to produce almost 12 million electric motors a year and a total workforce of 2300 people (Kementarian Perindustrian, 2012). In that context, local production of medium sized electric motors may be quite feasible, making use of previous experiences and present production of small size motors.

3.11 EE-EMDS: needed investment and installation workforce

Table 7 gives the average yearly needed investment, labour cost and workforce for implementing additional efficiency measures, besides only replacing an electric motor with a more efficient type. This should be seen as expanding a MEPS programme towards a complete system approach. This analyses has been done in Appendix K.

The one but last row repeats the total investment cost for a MEPS on IE4, taken from **Table 17** and **Table 19**. The labour costs mentioned in this row concerns only the working hours and does not take into account any additional costs for food, travel and hotels. The last row shows with a factor the increase in investment costs and needed man-years relative to the IE4 MEPS scenario only.

Table 7: Additional yearly average investment and work-force needed when a MEPS programme is expended with a focus on EE-EMDS's

Type of energy efficient electric motor driven system (EE-EMDS)	Total investment (bln IDR)	Total investment (mln USD)	Total installation costs (bln IDR); only labour	Total installation costs (mln USD); only labour	Needed man-years
Pumping	11,535	864	352	26	2,999
Compressed air	8,277	620	211	16	1,793
Fan	5,757	431	88	7	753
Total	25,569	1,916	651	49	5,544
Compare IE4 MEPS only	3,207	240	35	3	326
Multiplier (IE4/EE-EMDS)	8	8	19	19	17

We can conclude that 8 times more investment is needed. This still represents cost effective investments, with a simple payback time of maximum three years. Since these measures are more complex and time consuming to implement, and since we assume that as well systems driven by electric motors smaller than 11kW will need external engineer, the total labour costs and needed man-years will increase with a factor 18.

4 Segregation by sub-sector

4.1 Key messages

Electricity consumption 2009 by subsector

- The four industries with the highest electricity consumption are: textile and clothing, chemicals, food and beverages, and iron and steel

Electricity intensity 2009 by subsector

- The four industries with the highest electricity consumption for each enterprise are again iron and steel and chemicals, complemented with pulp and paper and machinery.

Savings potential 2025 by subsector

- The four industries with the highest savings potential for energy efficient electric motor systems are again iron and steel, complemented with textile and clothing, food and beverage and cement
- Of these, the iron and steel and cement industries are promising candidates to engage with to test policy ideas, as they have only a single main industry association each
- The commercial sector *as a whole*, has about the same savings potential as compared to all medium and large size enterprises within the industrial sector.

4.2 Chapter introduction

In the previous chapter, we have analysed the industrial as a whole. Obviously, the industrial sector can be split-up into several industrial subsectors. In this chapter, we try to get a better quantitative feeling for each subsector in terms of electricity consumption and savings potential. This will help us as well in prioritising the next phase of the project.

The chapter is broken down in the following way:

- Section 4.3 first looks at the electricity consumption by subsectors for 2009
- Section 4.4 estimates the electricity intensity by subsector for 2009, expressed in electricity consumption each enterprise and each employee
- Section 4.5 estimates the savings potential by subsector for 2025
- Section 4.6 estimates the savings potential by subsector for 2025 for other fuels that is used to generate own electricity

4.3 Electricity consumption 2009 by subsector

The National Statistical Bureau of Indonesia (BPS, 2015) describes 24 manufacturing subsectors in terms of number of employees, added value, etc. This division follows the 'International Standard Industrial Classification of all Economic Activities (ISIC), (UN, 2008). The following segregation in terms of size of enterprise is in use:

- Micro and small size Industry: number of employees less than 20
- Medium and Large size Industries: number of employees equal to or above 20

For certain groups of subsectors, the Ministry of Industry provides energy consumption by type of fuel for the year 2009 (MoI, 2010).

Table 8: Statistical data for medium and large size enterprises

	ISIC division	Medium and large size enterprises	Number of enterprises	Number of employees	Average employees each enterprise	Electricity consumption (GWh)
		Year:	2009	2009	2009	2009
1	10+11+12	Food, Beverage, and Tobacco	6,921	1,050,728	152	3,208
2	13+14+15	Textile, leather, shoe, sandal	5,444	1,188,272	218	5,351
3	16+31	Wood, furniture, and forestry	2,924	391,235	134	611
4	17+18	Pulp & paper, print industry	985	163,163	166	1,911
5	20+21+22	Chemical, fertilizer & rubber industry	2,785	552,677	198	5,161
6	23	Cement and non-metallic	1,696	168,943	100	2,270
7	24+25	Iron and Steel industry	1,189	203,975	172	2,784
8	28+29+30+33	Machinery industry	908	205,484	226	1,609
9	26+27+32	Other	1,543	414,557	269	1,982
		Total medium add large enterprises	**24,395**	**4,339,034**	**178**	**24,886**
		Total small scale enterprises 2010	**2,732,724**	**6,447,260**	**2**	**21,318**
		Total whole industrial sector	**2,757,119**	**10,786,294**	**4**	**46,204**
		Medium and large % of whole sector	**0.9%**	**40%**		**54%**

In Table 8 we have combined statistical data for the medium and large size enterprises[12]. We have also done the same for micro and small enterprises (not shown here). To get more feeling for the results, a comparison with data from the Netherlands is added (third quarter of 2012) to Appendix M. Appendix L gives an overview of Indonesian associations each industrial sector.

12 Note that subsector 'Manufacture of coke and refined petroleum products' (ISIC division 19) is excluded from the data.

From this analysis we can conclude that:

1. Medium and large size enterprises comprises only 1% of all enterprises in Indonesia by number. In the Netherlands this percentage lies at 9%.
2. The average number of employees for micro and small size enterprises is only 2,4 employees for each enterprise ('establishment', according to Indonesian statistics). For micro size establishments this in only 2; for small size establishments this is 8. For medium and large size enterprises, this number is higher; an average of 178 employees each enterprise.
3. Due to these numbers, the 1% of medium and large size enterprises give work to 40% of all employees in the industrial sector. In the Netherlands the conclusion would be that the 9% of medium and large size enterprises give work to 80% of all employees in the industrial sector.
4. With the electricity consumption data from the Ministry of Industry (MoI), we can conclude that these 1% of medium and large size industrial enterprises are responsible for more than half of the total electricity consumption (54%). This means as well that, by contacting the 1% of medium and large size enterprises first, we can discuss energy saving options that target 54% of total electricity consumption. This is a very cost effective way in terms of enforcing implemented governmental policies. For the Netherlands the conclusion is similar; although the percentages differ: the 9% of medium and large size industrial enterprises are responsible for 83% of the total electricity consumption.

5. The top 4 subsectors with highest electricity consumption for medium and large size enterprises is mentioned below. The percentage in brackets indicates the share of electricity consumption the middle and large size enterprises are responsible for, within their own subsector.

   - Textile, leather, shoe and sandal industry (58%); 2 main industry associations
   - Chemical, fertilizer & rubber industry (90%); 5 main industry associations
   - Food, Beverage, and Tobacco (36%); 4 main industry associations
   - Iron and Steel industry (61%); 1 main industry association

   In the Netherlands the latter three belong to the top-4 as well, completed with the Machinery industry.

4.4 Electricity intensity 2009 by subsector

In **Table 9** the electricity consumption has been divided by number of enterprises and employees, giving energy intensities. The intensity by enterprise gives more or less an indication for the relative efficiency of efforts by e.g. governmental officials, to discuss energy efficiency with individual firms.

Table 9: Electricity intensity by enterprise and employee

	ISIC division	Medium and large size enterprises	Average electricity consumption each enterprise (MWh)	Electricity consumption each employee (kWh)
		Year:	2009	2009
1	10+11+12	Food, Beverage, and Tobacco	464	3,053
2	13+14+15	Textile, leather, shoe, sandal	983	4,503
3	16+31	Wood, furniture, and forestry	209	1,562
4	17+18	Pulp & paper, print industry	1,940	11,711
5	20+21+22	Chemical, fertilizer & rubber industry	1,853	9,338
6	23	Cement and non-metallic	1,339	13,437
7	24+25	Iron and Steel industry	2,341	13,648
8	28+29+30+33	Machinery industry	1,772	7,830
9	26+27+32	Other	1,284	4,781
		Total medium add large enterprises	**1,020**	**5,735**
		Total small scale enterprises 2010	**8**	**3,307**
		Total whole industrial sector	**17**	**4,284**

The top 4 of subsectors with highest electricity consumption each enterprise is mentioned below. *Italic* writing has been applied to indicate that this subsector already was part of the previous top-4.

- *Iron and Steel industry (61%); 1 association*
- Pulp & paper, print industry (68%); 2 associations
- *Chemical, fertilizer & rubber industry (90%); 5 associations*
- Machinery industry (87%); 4 associations

In the Netherlands as well [Chemical, fertilizer & rubber] and [Iron and Steel] belong to the top-4[13].

4.5 Savings potential 2025 by subsector

So, what subsector should have our first focus? To answer that question, we try to find the subsectors with the highest electricity savings potential for electric motors. From (Almeida et al, 2003) we know for each subsector the share of electricity consumption by electric motors, and what system is driven by these motors. See Appendix N and Appendix O for the details.

The MoI has given a forecast of electricity consumption for 2025 (MoI, 2010). After combining this with previous findings, we can produce the **Table 10**[14].

13 Note that the electricity consumption each employee lies a factor 7,7 higher compared to Indonesia. This is a well know phenomena; as a comparison, according to (Wikipedia, 2015), the total energy consumption per capita lies a factor 6,6 higher. In a country as Indonesia, less industrial processes are automated. As a consequence, there is a larger need for workforce. This means as well that there will be relatively less electric motors, which you would normally find in automated processes, as conveyors.

14 The share of electric motors and related savings potential in the [Textile, leather, shoe, sandal] industry is estimated by us, taking into account findings in (GIZ, 2013).

Table 10: Prioritising the programme by subsector; highest savings potential EE motors and VSD's

			1	2	3	4
	ISIC division	Medium and large size enterprises	Electricity consumption GWh	Electricity consumption electric motor systems GWh	Electricity savings potential motors & VSD's GWh	Electricity savings potential motors & VSD's in pumps, fans, compressors GWh
		Year:	2025	2025	2025	2025
1	10+11+12	Food, Beverage, and Tobacco	11,191	10,049	744	449
2	13+14+15	Textile, leather, shoe, sandal	11,899	3,570	791	292
3	16+31	Wood, furniture, and forestry	849	559	57	21
4	17+18	Pulp & paper, print industry	3,965	2,978	204	188
5	20+21+22	Chemical, fertilizer & rubber industry	12,799	9,203	223	158
6	23	Cement and non-metallic	6,996	6,359	1,409	634
7	24+25	Iron and Steel industry	4,600	3,050	667	246
8	28+29+30+33	Machinery industry	7,050	3,645	471	177
9	26+27+32	Other industry	5,567	3,335	207	128
		Total industry sector	**64,916**	**42,747**	**4,774**	**2,293**
10		Commercial sector	128,056	49,046	4,499	3,712
		Total industry plus commercial	**192,972**	**91,792**	**9,273**	**6,004**

Columns 3 and 4 give the information that we are searching for. Column 3 gives us the electricity savings potential for electric motors, including VSD's. Column 4 gives the same, but only for the priority driven systems. The top-4 of both columns are the same and should from this perspective have the highest priority:

- Cement and non-metallic industry, 1 association
- Textile, leather, shoe and sandal industry; 2 associations
- Food, beverage, and tobacco; 4 associations
- Iron and steel industry; 1 association

From these four subsectors, [Cement and non-metallic] and [Iron and steel] have relatively high electricity consumption each enterprise (**Table 9**). At the same time, they only have one association to discuss a possible MEPS programme with. The other two subsectors on the other hand, have a relatively low energy intensity and more associations to deal with. This makes these two subsectors in theory and from this perspective ideal as a first focus. In chapter 5 we will add information to these sectors on past and present initiatives, focussing on energy efficiency.

Note that the commercial sector *as a whole* (row 10), has about the same savings potential, compared to all medium and large size enterprises within the industrial sector.

4.6 Savings potential for other fuels

All calculations so far, where based on the amount of electricity, delivered by PLN. But in Indonesia, enterprises generate their own electricity as well. From (MoI, 2010) we know the consumption of medium and large enterprises, of fuels other than electricity, see **Table 11**.

Table 11: Energy consumption by type of fuel

			1	2	3	4	1+2+3+4	5
	ISIC division	Medium and large size enterprises	Gasoline GWh	Diesel GWh	Coal GWh	Gas GWh	Energy consumption 'other fuels' GWh	Electricity delivered by PLN GWh
		Year:	2009	2009	2009	2009	2009	2009
1	10+11+12	Food, Beverage, and Tobacco	878	10,526	1,942	743	14,089	3,208
2	13+14+15	Textile, leather, shoe, sandal	421	3,782	6,567	275	11,044	5,351
3	16+31	Wood, furniture, and forestry	52	864	55	20	991	611
4	17+18	Pulp & paper, print industry	165	978	913	551	2,607	1,911
5	20+21+22	Chemical, fertilizer & rubber industry	1,299	7,643	3,665	689	13,295	5,161
6	23	Cement and non-metallic	72	1,872	13,750	1,294	16,987	2,270
7	24+25	Iron and Steel industry	208	2,744	325	515	3,790	2,784
8	28+29+30+33	Machinery industry	269	2,143	-	442	2,854	1,609
9	26+27+32	Other industry	358	2,470	36	898	3,763	1,982
		Total medium and large enterprises	**3,721**	**33,022**	**27,252**	**5,426**	**69,421**	**24,886**

A significant part of the 'other fuels' (column 1+2+3+4) is used for own electricity generation. This means that in fact, electric motors make more running hours, using own produced electricity. We have estimated which part of the other fuels is turned into electricity within each subsector[15] (Ambarita, 2015), as shown in **Table 12**. From this table we can conclude that on top of the electricity delivered by PLN (column 1), enterprises on average produce 25% more electricity by themselves (column 2 and 3). When we take this into account, calculated energy savings potential so far (in absolute terms), will have been underestimated. The additional effect for avoided GHG emissions when following a MEPS programme will be more difficult to calculate, since for this we should take into account the mix of fuel used.

Table 12: Own electricity production by subsector

			1	2	3	4
	ISIC division	Medium and large size enterprises	Electricity delivered by PLN GWh	Own electricity production GWh	Own electricity production as a % of PLN	Total electricity consumption GWh
		Year:	2009	2009	2009	2009
1	10+11+12	Food, Beverage, and Tobacco	3,208	740	23%	3,948
2	13+14+15	Textile, leather, shoe, sandal	5,351	2,293	43%	7,644
3	16+31	Wood, furniture, and forestry	611	278	45%	889
4	17+18	Pulp & paper, print industry	1,911	730	38%	2,641
5	20+21+22	Chemical, fertilizer & rubber industry	5,161	149	3%	5,310
6	23	Cement and non-metallic	2,270	420	19%	2,690
7	24+25	Iron and Steel industry	2,784	265	10%	3,049
8	28+29+30+33	Machinery industry	1,609	799	50%	2,408
9	26+27+32	Other industry	1,982	659	33%	2,640
		Total medium and large enterprises	**24,886**	**6,332**	**25%**	**31,218**
		Total small enterprises	**21,318**	***5,424***	***25%***	***26,742***
		Total whole industrial sector	**46,204**	**11,756**	**25%**	**57,960**
10		Commercial sector	*33,258*	*8,462*	*25%*	*41,720*
		Total industry plus commercial	**79,462**	**20,218**	**25%**	**99,680**

15 Based on an average conversion efficiency of 35%

5

Developing a National policy framework for motor systems

5.1 Key messages

General message

- This chapter gives information on the process of developing a national policy framework for motor systems. It uses previous studies and literature to broaden that knowledge and to find best practices. It also gives guidance on how to continue to the next phase of the project.

Barriers

- We have noticed that many barriers to the introduction of EMDS found in other countries and described in literature, are valid for Indonesia as well. These include lack of awareness, investment decisions based on purchase costs and a large stock of old replacement motors. More specifically related to Indonesia, are barriers that relate to subsidized electricity prices, the import of low-cost Chinese motors, oversizing, motor rewinding policy, continuation of industrial production lines, smuggling and challenges of regulatory enforcement.

Policy toolkit

- A policy toolkit to overcome these barriers was introduced in Chapter 1. These tools do not work independently from each other, but are highly complementary. The interaction between these instrument, and the way they strengthen each other is described as well, just as the interaction with the different stakeholders. Existing Indonesian initiatives related to the individual policy options have been collected as a starting point for a future more comprehensive framework.

Motor market versus industrial subsectors

- In the previous chapter we had identified the top-4 industrial subsectors as a priority for our programme. We concluded that the [Cement and non-metallic] and the [Iron and Steel] industry were a key focus, followed by the [Textile] and the [Food, Beverage, and Tobacco] industry. With this chapter we can add that the [Textile] industry receives the bulk of electric motors from large Indonesian suppliers, which are probably at least level IE1. This implies that the remaining priority industries are likely to receive motors from smaller retail companies and/or through international orders. Possibly this includes a significant share of low quality IE0 motors (typically described as coming from China).

Motor market versus existing policies and activities

- So far, the [Iron and Steel] industry, seems to have received less attention in terms of existing policies and activities, whereas the [Textile] and [Cement] industry received most attention. Quite a lot of relevant activities have been undertaken so far, but with little true coordination. The challenge now is to make sure that this experience is utilized within this electric motor project, which gives input to form national policy on this topic.

5.1 Chapter introduction

This project gives input to the strategy for a National Policy Framework for electric motor systems. A strategy like this, has been developed in countries before. A few sources have collected best practices observed in other countries and turned them into useful Policy Guidelines, as:

- Motor MEPS Guide (EMSA, 2009)
- Motor policy guide, part 1: assessment of existing policies (EMSA, 2011)
- Policy guidelines for electric motor systems, part 2: toolkit for policy makers (EMSA, 2014b)
- Energy efficiency in electric motor systems: technical potentials and policy approaches for developing countries (UNIDO, 2011)
- Energy-efficiency policy opportunities for electric motor-driven systems (Waide & Brunner, 2011)

We have made use of these sources while developing this report and recommendations. The challenge now is to use stakeholders feedback to turn best practices of similar programs into a strategy that works best for Indonesia. This strategy should take into account the specific context and aspects of Indonesia, e.g. cultural, political, and business aspects. In this chapter we will follow more or less the structure of (EMSA, 2014b), although in a different sequence. Some text is directly copied into this document (see *Italic text*), after which we have added feedback, gathered from stakeholders, relevant for that specific topic.

Key stakeholders

The most effective government policies are those that stimulate action amongst key stakeholders within the motor systems market to achieve long term market transformation. A comprehensive range of policies are therefore required to influence international/national standard makers, industry associations, industrial users and power utilities (EMSA, 2009).

Figure 22: Influence of National Policy Makers (EMSA, 2009).

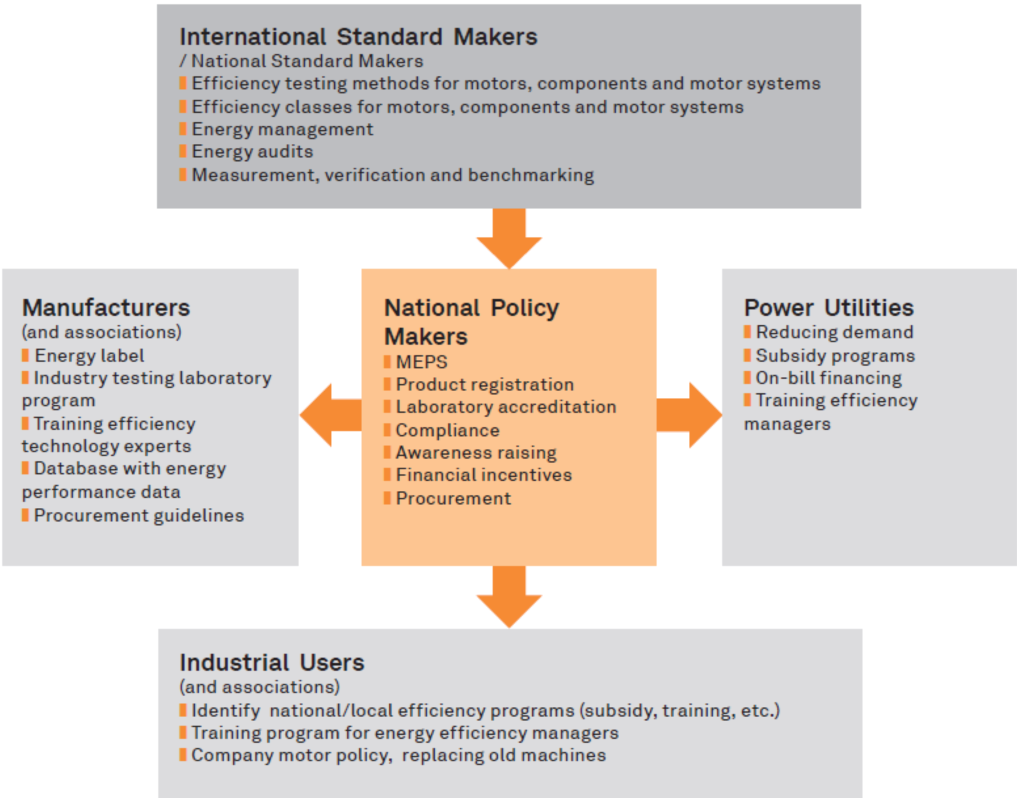


Figure 22 illustrates the potential for policy interaction among key stakeholder. So far, we have conducted 17 interviews with several stakeholders:

- 5 market players (manufacturers, vendors)
- 3 organizations with data and knowledge of the electric motor market in Indonesia
- 3 organizations with relevant running programs in Indonesia
- 3 governmental stakeholders
- 1 organisation involved in setting up testing facility
- 1 association
- 1 industrial end-user

For each interview we have written a report of a few pages and out of this, the main findings are categorized and added to this chapter anonymously.

Common strategy

While the specifics may differ in each country, formulating a national policy framework for energy efficient electric motor systems, requires the use of processes common to the development of good policies in general. In fact, the steps below can be applied to any other energy consuming system, e.g. a policy program for energy efficient lighting.

Typically the following general steps are involved:

1. Establish clear policy objectives (section 5.2)
2. Identify the existing barriers to meeting these objectives (Section 5.3)
3. Identify most appropriate policy tools (Section 5.3)
4. Gather relevant information and data on the market (Section 5.4)
5. Identify existing policies or activities that may be relevant (Section 5.6)

In the Sections that follow, these steps will be discussed further within the Indonesian context. The chapter ends with looking ahead to the second phase.

5.2 Establish clear policy objectives

While the overall aim of motor policies may be to maximize energy savings or reduce greenhouse gas emissions, motor policies may be established to achieve a number of objectives. Included amongst such objectives may be the establishment of a sustainable energy efficiency industry, the development of professional expertise and the reduction of industry costs to make them internationally competitive. The setting of clear objectives from the outset will help guide the selection of an appropriate mix of policy measures (EMSA, 2014b).

Quantifying the project helps to set clear objectives and has been done in Chapter 3. Comparing these with other governmental mitigation initiatives is helpful as well. In a parallel project, ECN tries to set up a strategy to make this possible. The strategy is called 'Common Accounting Framework for Energy' (CAFE). The CAFE could have the following elements, as much as possible quantified:

Table 13: Example of elements of the CAFE, comparing the impact of energy efficiency initiatives

Impacts	Financial	Feasibility
Climate (GHG reduction, adaptation/resilience)	Marginal abatement costs	Structure
Economic (subsidy reduction, end-user savings, energy security)	Financial mechanisms	Financial feasibility
Social (jobs, health, education, other)	Financing needs	Technological feasibility
Environmental (water, soil, air)	Government contribution	Risk assessment
Transformation / paradigm shift	Private sector contribution	Progress towards targets (for actions already implemented)
	International contribution	
	Exit strategy	
	Status of funding	

In terms of project impact, we believe that the focus should be at the whole system that is driven by the electric motor, instead of only introducing MEPS. Obviously, this needs a more comprehensive policy program. As well, more stakeholders will be involved.

5.3 Identify existing barriers to meet objectives

Barriers are to be found at several levels and sectors. In (Waide & Brunner, 2011) a complete chapter has been written on possible barriers and the ways to remove these. It even starts at international trade, e.g. technical barriers such as grid voltage and frequency. After that, we can identify barriers at the level of the manufacturing sector and the business level (import, wholesale, local trade). Maybe most importantly, end-users will face several barriers that prevent investment in energy efficient motor systems in the first place, and these may vary by type of industry or size of enterprise.

As well (Almeida et al, 2003) describes barriers, categorized as (1) barriers for adopting energy efficient electric motors and VSD's, (2) economic barriers, (3) internal conflicts and (4) barriers related to market structure. Measures to overcome these barriers are categorized in (1) educational/promotional needs and (2) financial measures. Note that these two solutions are part of the policy tools of Section 5.4.

It is very important to identify these barriers for each user-group and gain a good understanding of their relative impact in order to assess which policies are likely to be effective. Most barriers are actually not specific to electric motors and could apply as well when introducing other energy efficient devices, as energy efficient lighting. (EMSA, 2014b).

End-user barriers according to international literature

We have noticed that many barriers found in other countries and described in literature, are valid for Indonesia as well. These are well-known barriers. Generally, the sales cycles passes from the manufacturer (with adequate knowledge) to wholesale (without adequate knowledge) to the end-user (without adequate knowledge). This often gives rise to:

- A lack of awareness of the savings potential of energy efficient motor systems at several levels
- Investments based on first-costs (investment costs) and not on life-cycle cost assessments
- Lack of know-how for efficient use of motor systems (complexity, outdated engineering skills)
- Large stock of old replacement motors

More specifically related to Indonesia, we have added the following remarks made by interviewees.

Money: purchase price

- The lower the negotiated purchase price compared to the catalogue price, the higher the managers' reward for the purchaser. Quality and expected life time is not taken into account in this reverse-incentive system.
- Due to this investment based on first-cost, established companies as Teco, Tatung and ABB expect difficulties competing with cheap, low-quality electric motors from China, when they would promote high efficient motors.

- In situations with low running hours a year, it should not be necessary to buy a relatively expensive (high) efficient electric motor. See as well Section 3.6 for information on the pay-back period, heavily depending on running hours.

Money: electricity price, price over life time, return on investment

- Electricity costs are minor to the industrial total costs. For Indonesia this is even more true due to electricity subsidies. Only when the subsidy system changes, there could be a change in mind-set for managers. Since the last increase of the electricity price a few months ago, dealers do sense this first change; purchasers do start to request information on more efficient motors.
- On the other hand, large factories have their own diesel generators as a back-up and for peak load. Diesel consumption is expensive, which is an incentive to reduce electricity consumption. In Section 4.6 we have estimated that companies produce 20% of their total electricity consumption themselves.

Motor policy: rewinding, keeping the production line running

- The production line should never be on-hold. Financially seen, this is the worst thing that can happen in the industry. Therefore rewinding an electric motor is common in Indonesia since this is the fastest way to get the motor and production line running again. When rewinding smaller motors, the efficiency is equal to the original motor, or worse. This very much depends on the original motor quality, the copper wire used and the skills of the individual person rewinding the motor. There are professional rewinding companies, but that takes more time. As we heard in one anecdote, the car mechanic around the corner is able to rewind as well, much faster, against lower cost, and obviously with a much lower final efficiency. In such an instance the efficiency may drop by up to 10% due to the use of low quality and thin copper wire. A factory employee is rewarded when he manages to get a motor that went down repaired quickly. This is of course logical, when this means the production line is back in operation again.

Motor policy: oversizing

- Another problem in terms of efficiency are the oversized motors. This will keep the motor running in partial load, which is not good for the efficiency. There always has been the tendency to oversize a motor, with good reasons. When the load of a motor is too high (e.g. 120%), the motor produces too much heat; insulation and copper wiring will be damaged. Often this can be repaired through rewinding, but not always (depending on the damage). Here lies a relation with the cheap Chinese motors that are often bought, which are reported to be more prone to poor performance at full load over longer periods. When choosing a new motor, purchasers are not aware of the fact that a smaller size but higher quality product may be just as suitable for the job.

Awareness and training: industries

- In some larger and/or international industries, there actually is an adequate understanding of energy savings potential, but always relying on expertise from abroad. Such an approach excludes the ability of rapid action when required (e.g. engineers from India being available within a weeks' time). These industries do buy high efficient electric motors, even through local vendors in Jakarta. Examples are the chemical and gas- and oil-industry; however, smaller industries lack the knowledge and the initiative. Interesting to realize is that smaller scale local vendors themselves often are not aware of the concept of high efficiency motors.

- The employees working with motors and pumps, are not trained to operate the system in an efficient way. Employees in a factory on a process line are not likely to be concerned about the running costs. They would e.g. not turn them off during night time. From some interviewees it was even mentioned that factory managers may prefer to keep employees ignorant about cost related aspects.

Awareness and training: trading companies

- The bigger international electric motor manufacturing companies do have high efficient motors in stock, but only for the larger size motors. They don't use it as a selling argument, but just mention the efficiency. But, together with the customer, they do calculated payback time for a specific application. For the larger motors, the total return on investment over life time will be taken into account. For smaller motors, it is often about the short term.
- Traders in between the previous manufacturers and end-users, don't have appropriate knowledge to give information about the payback time over lifetime of more efficient motors. The total return on investment over the life time will not be calculated, except for larger motors

Enforcement and smuggling

- Retailers can attach a nameplate to any electric motor, indicating that it is high efficiency. This is difficult to check, since you need to look at serial numbers etc. From the outside, electric motors generally look similar.
- The larger international industries (e.g. gas and oil) already have their own motor policies for high efficiency motors. If there is the perception that they will have to pay significant cost increases, smaller industries may try to avoid MEPS regulations. Therefore, there may be an incentive for suppliers to offer electric motors that will have fake IE-coding.
- Brochures and catalogue with electric motor specifications cannot always be trusted in terms of mentioned efficiencies. We heard of an example of an international motor manufacturer finding its own brochures being copied by a local trade company, with changed information.
- A few times it was mentioned that even when the government introduces mandatory MEPS, it is expected that cheap Chinese motors will still enter the country through smuggling.

Proposed governmental actions, remarks made

- Interviewees mentioned that the policies, regulations and procedures concerning the implementation of governmental energy efficient programmes are often unclear.
- The government needs to introduce a mandatory program that includes both penalties and rewards to industries to enforce the implementation of energy efficiency programs.
- Indonesia needs a public campaigns to inform the end user about efficient motors and the intended implement of MEPS.
- Testing should be done by independent third parties, not governmental related organizations.

- A worry is that legislation of MEPS/Labels will only apply to the larger registered companies. Small companies that import cheap electric motors from China might not be regulated.

5.4 Identifying appropriate policy tools

Policy toolkit and the interaction with stakeholders
This Section provides a short overview of policies most commonly used to promote increased efficiency in motors and motor systems and to overcome the barriers mentioned in the previous Section. For a more extensive overview, including a number of examples, consult the main sources of literature as mentioned in Section 5.1. In Appendix P a comprehensive overview of these key policy instruments and their attributes is given. These tools do not work independently from each other but are highly complementary. The interaction between these instrument, and the way they strengthen each other, is given in Appendix Q. Below, the possible interaction of these policy tools and key stakeholders is described.

- Minimum Energy Performance Standards; MEPS
- Awareness and information campaigns
- Labels
- financial incentives
- Energy audits
- Energy management systems
- Motor policy
- Voluntary agreements

Minimum Energy Performance Standards; MEPS determine what IE-class of electric motors is manufactured in and imported into the country. MEPS regulate what customers are able to purchase, restricting them to higher efficiency products. Simple **awareness and information campaigns** are needed to give the end-users, purchasers and sales individuals a *first impression* about energy savings options, the availability of energy efficient electric motors, the possibility to look at the whole motor-driven system, and related financial benefits, including the payback period over life-time. To make this rather complex field of expertise more accessible and understandable, **labels** could be added to mechanical equipment such as pump, fans, air compressors and even to interconnecting equipment as a clutches, gears or transmission belts. This helps the end-user, purchaser and sales staff to easily identify better-performing products.

Although payback periods are often relatively short, for example less than 3 years, energy efficient equipment will typically be more expensive upfront to purchase, especially in the beginning when such products have low market shares. To overcome these issues, the government can decide to stimulate market transformation in the beginning by offering **financial incentives.**

For a company to understand the real possibilities for cost-effective energy savings, often external experts are needed to do the company specific inventory, analysis and calculations. These can be hired from abroad (as happens at the moment), but the government can decide as well to establish a national body of skilled **auditors** able to sell services to the market. Industrial associations and power utilities (such as PLN) can support this process. The government can offer financial incentives for this process as well.

Out of this process, the necessary skills to establish **energy management systems** and **motor policies** should be promoted. Corporations will need to develop an understanding of energy savings to change their business culture permanently. This includes monitoring of energy consumption, implementing maintenance programs and keeping track of inventory lists of running equipment and spare-parts. As soon as there is a failure in a production line, engineers will need to be able to act, taking into account the new energy efficiency culture. This means replacing a broken device by a spare one, with the same, or better efficiency, instead of an ad hoc fast but low quality solution (such as rewinding an electric motor).

Figure 23: The relation between policy tools and stakeholders

Support:	**Government, PLN, Power Utilities and Associations**	**Direct impact**	**Speed**	**Costs**
Target:	**Manufacturer Importer** → **Sales EE motor, pumps, fans...** ← **Purchaser** ← **Industrial sectors Individual businesses**			
Tool:	**MEPS**	**high**	**3-5 years**	**high**
	Awareness and Information	**low**	**quick**	**varies**
	Labels	**high**	**1-2 years**	**low**
	Financial Incentives	**medium**	**quick**	**varies**
	Energy Audit	**medium**	**quick**	**varies**
	Energy Management	**medium**	**1-2 years**	**varies**
	Motor Policy	**medium**	**quick**	**low**
	Voluntary Agreements	**medium**	**quick**	**low**

When it comes to a whole industrial sub-sector, in collaboration with the related association, the government can set up **voluntary agreements** for agreed future efficiency improvements through non-regulatory mechanisms. Once such a framework is established, in can be quickly implemented. Voluntarily agreements can be supported financially by the government. Although the agreement is based on voluntarily principles, it can incorporate the agreement that any received financial support should be given back when targets have not been achieved. The industrial association is typically involved in terms of monitoring, verification and publications.

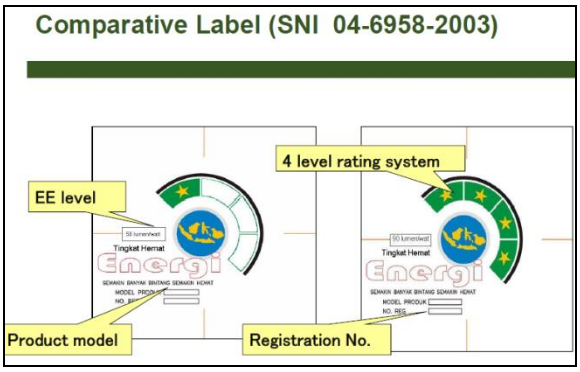
In the following Sections, the policy tools are described further, including relevant Indonesian aspects.

5.4.1 MEPS and Energy Labels

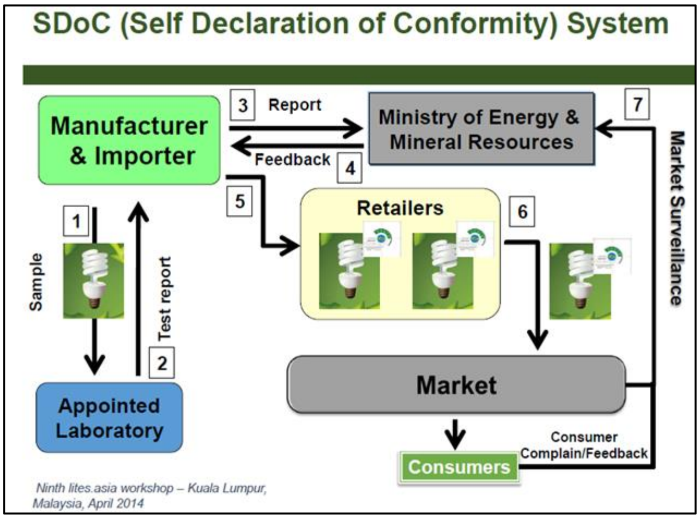
Many countries and regions have introduced Minimum Energy Performance Standards (MEPS) and labels for electric motors. A database with information on 20 countries is given by (Clasp, 2015). If we analyse this information, we see that:

- Almost all countries (19) have introduced MEPS
- From these, 15 countries (75%) have chosen for *mandatory* MEPS.
- From these, 6 countries chose the combination with a so-called comparative label (4 countries) or endorsement label (2 countries).

The government of Indonesia has decided to introduce mandatory MEPS for medium and large size electric motors at the starting level of IE1 and are in the process of preparing this. The focus of our project is on extending that program towards electric motor driven systems, whereby members of the existing MEPS Technical Working Group (TWG) were asked to be involved. The TWG comprises government officers from various ministries (energy, trade, industry), stakeholders (motor manufacturers and importers), academia, and the Indonesian standards body. In previous deliberations, the TWG decided not to combine MEPS with labels for the initial introduction of motor MEPS in Indonesia. Energy labels were seen as less effective for industrial equipment.



For other, smaller electrical appliances, including packed devices that have small size electric motors, comparative labels will be introduced. The design will provide information on the absolute energy efficiency and an energy efficiency star rating of four stars. The star rating is to be assigned by an independent and accredited test facility that tested the product (APERC, 2012).



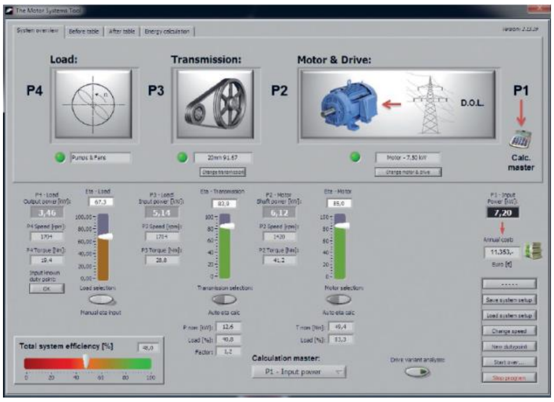
Enforcing of electric motors MEPS at the customs level will probably follow a similar strategy as the enforcement of the already established CFL Labelling Program (see figure at left).

In terms of testing and compliance, in Indonesia BRESL[16] was involved in setting up a testing procedure for electric motors, in collaboration with BPPT, with a capacity up to 274 kW.

5.4.2 Raising Awareness and Information Provision

Lack of information is often one of the main reasons why companies do not consider energy efficiency measures, with decision makers either unaware of the energy saving technologies available or of how they might be implemented within their own organization. The objective of an information provision policy is to overcome this barrier by targeting key personnel and decision makers within companies to fill this information gap. Many personnel within an organization are responsible for decision-making. It is therefore important when planning an activity that the information materials target each of these personnel with information appropriate to their needs. This includes (EMSA, 2014b):

- *General awareness-raising material and activities, such as best-practice case studies and energy efficiency awards.*
- *Technical assistance materials, such as guides and training.*
- *Self-assessment materials, such as energy saving/system optimization calculators, life-cycle costing methodologies and benchmarking tool*



Internationally, there are many calculation and information tools available through the Internet. In (EMSA, 2014b), there are seven mentioned. As an example, IEA4E provides the Motor Systems Tool[17]. A calculation tool intended for engineers, machine builders, energy consultants and others interested in motor systems optimization. It consists of a full motor system from power supply to application. From one known duty point all partials are calculated as well as the total system efficiency. Any change in speed, load or components is calculated dynamically and results are presented instantly (EMSA, 2014a).

As well (Siemens, 2015) has several ‘selection and engineering tools’. Some of these translated in Bahasa Indonesia could be very useful.

[16] BRESL, UNDP, www.bresl.com

[17] http://www.motorsystems.org/motor-systems-tool

Premium Efficiency vs. Standard Efficiency

If you operate a 25 HP premium efficiency motor at full load for 24 hr. a day (8760 hr. per yr.) and your cost per kilowatt hr. is 9 cents, you can save $532.00 annually.

This comparison is based on a premium efficiency motor with a 94.1 efficiency rating vs. a high efficiency motor with a 91.0 efficiency rating.

Increased efficiency leads to lower operating temp., resulting in longer life.

Cool Operation: The life of an insulation system doubles for each 10°C reduction in operating temp.

Longer Bearing Life: The lower the temp., the longer the bearing grease will last.

Annual Savings = $0.746 \times HP \times L \times C \times N \left(\frac{100}{E1} - \frac{100}{E2}\right)$

HP=Motor Horsepower

L = Percent Load Divided by 100

C = Energy Cost, Dollars per kW Hr.

N = Running Time, Hr. per Yr.

E1 = Efficiency (%) of Standard Efficiency Motor

E2 = Efficiency (%) of Premium Efficiency Motor

A catalogue can inform the purchaser about the financial benefits of choosing a high efficient motor, as the example on the left shows (Grainger, 2015).

Some related information and efforts specific to Indonesia (APERC, 2012):

- The 'National Energy Efficiency Movement' of the Ministry of Energy and Mineral Resources promotes energy conservation awareness through seminars and workshops, talk shows, public advertisements, brochures and leaflets; it is directed to households, specific industries and transport. The state-owned electricity company PLN promotes energy conservation in electricity use. Other institutions also promote awareness, including the Agency for the Assessment and Application of Technology (BPPT).
- The Energy Efficiency and Conservation Clearing House Indonesia (EECCHI)[18] is a centre for data and information related to energy efficiency and conservation activities. Note that as of 2015 the operation of EEECHI seems to be limited and the website was not functioning.

5.4.3 Energy Audit Programs

An energy audit is the systematic inspection and analysis of energy use and energy consumption of a system or organization with the objective of identifying energy flows and the potential for energy efficiency improvements, Audit programs are policies and initiatives that encourage companies to undertake an energy audit. They may be mandatory or voluntary and usually include the provision of support in the form of audit tools and often assistance from professional energy auditors (EMSA, 2014b).

During our interviews, we have noticed that the larger international industrial companies follow relatively high standards when it comes to maintenance and energy savings. This includes energy audits, often performed by international experts. One interviewee mentioned that 'it was not possible to find the right engineering skills in Indonesia'. In the audits that we discussed with interviewees, the company would accept all energy saving options that had a pay-back time of less than 2 years, described as 'low hanging fruit'. This maximum had been chosen because of unpredictable oil price fluctuations, government regulations and companies' economic situations.

[18] https://twitter.com/eecchi

Often a Variable Speed Drive (VSD) was involved in the recommendation. This is simply because of the fact that so many electric motors are just running continuously at full speed, while the demand is low. In other interviews, Teco and ABB also mentioned the large savings potential of VSD's.

Government Regulation No. 70/2009 on Energy Conservation state (Eincops, 2011b):

- Obligation for high energy consumer (min 6000 TOE/year) to conduct energy audits periodically and appoint energy managers
- Energy audit is conducted by internal energy auditors and/or by accredited body
- Energy manager and energy auditor must have competence certificate as required by the legislation.

Year	Certificate		Total
	Energy Manager	Energy Auditor	
2012	50	0	50
2013	34	31	65
2014	-	8	9
Total	84	39	123

In 2011 a government programme was set up to provide for this (Eincops, 2011a; Eincops, 2011b). According to (HAKE, 2014), there are now certified energy auditors who have audited hundreds of companies. We have not met with these auditors or seen their detailed reports. However, the strong anecdotal evidence is that these audits are not particularly detailed. It is also unclear if the recommended actions are being implemented as there is not, to the best of our knowledge, any monitoring of the outcomes following audit.

5.4.4 Energy Management Programs

Energy management is the term used to describe the systematic and structured approach for reviewing the energy needs of a company and for implementing measures to reduce consumption, including putting in place on-going monitoring and reporting systems (EMSA, 2014b).

The Regulation No. 70/2009 on Energy Conservation referred to above is formulated to require larger energy consumers to conduct 'energy management', of which the aforementioned audits are one element. That regulation requires these firms to appoint an energy manager, formulate an energy conservation programme, conduct periodic audits with recommendations and report on energy use to ESDM. These are a strong starting points for energy management in Indonesia, but are not as strict as good practice for energy management systems would dictate. It is also unclear how this regulation is enforced or how impacts are monitored. Interviewees felt that impacts were likely to be marginal and that not all firms were reporting energy use in a way that could encourage conservation. It was suggested to us that most companies in Indonesia do not have any true energy management system in place in a way that could identify and lead to energy savings.

In addition, UNIDO implements a programme promoting ISO 50001 Energy Management Systems in Indonesia as part of the overall project ‘ Promoting energy efficiency in the industries through system optimization and energy management standards’ (UNIDO, 2014). This project targets four priority industrial sectors: textiles and garments, pulp and paper, food and beverages, and chemicals. UNIDO has provided trainings to roughly 400 individual companies. As well 23 ‘local experts’ have received additional trainings on energy efficiency of pumps, compressed air systems and steam production. The implementation of ISO 50001 in those companies that have received training and monitoring of outcomes is ongoing for the majority of firms. Pilot results for applying the ISO 50001 methodology are available and suggest good results.

5.4.5 Company Motor Policy

A motor policy provides a mid- and long-term strategy for the adoption of efficient motor systems throughout a company or plant, for integration within the company’s business planning framework. The aim is to achieve the most cost-efficient motor systems justified under economic conditions. A motor policy typically covers the following aspects (EMSA, 2014b):

- *A set of purchasing criteria.*
- *Establishing an inventory list*
- *Requirement for installation or acceptance tests*
- *Requirements for repair and maintenance*

Anecdotal evidence suggest that most firms in Indonesia, even in larger organisations, do not have a motor policy in place. This is in line with the feedback we received on energy management systems and the way they are currently promoted.

Despite this, from our own site visits, one of the international industrial companies that we have interviewed showed us an impressive database with each and every electric motor and pump available in the factory, including specifications. We were told each day they collect data on the performance of all motors and have to report on it. The company only has medium size electric motors as spare parts in stock. When a motor brakes down, the spare one will be placed. The one that went down will be rewound when possible and becomes the spare one. The larger motors are too expensive to have as spare once in stock. But this international factory has two production lines, so production will never go down.

5.4.6 Financial Incentives

Financial incentives use the provision of a monetary benefit to individuals or organizations to encourage actions that might not occur otherwise. They include a range of tools. Examples discussed in (EMSA, 2014b):

1) Public-Private Financing Partnerships
2) Dedicated Credit Lines,
3) Risk Sharing Facilities
4) Grands and Rebates
5) Loans
6) On-Bill Financing
7) Tax Incentives
8) Accelerated depreciation, Tax credits or tax relief, Differentiated VAT
9) Contracting and ESCOs
10) Energy saving performance contracting, Energy supply contracting,
11) Leasing

According to (APERC, 2012), the government, in accordance with the action plan (Governmental Regulation No. 70/2009), is expected to introduce government incentives that include tax exemption and fiscal incentives on imports of energy saving equipment and appliances, and special low interest rates on investments in energy conservation in the near future.

The Indonesian government through the Ministry of Industry has provided funding for the industry sector in order to improve the efficiency of plants and the Ministry of Energy and Mineral Resources are proposing similar financing through the government budget to promote and accelerate energy efficiency achievement. We are at the moment not aware of the status of this intention.

The government seeks to gradually remove fuel and electricity subsidies, and to bring their retail price to reflect the cost of supply. In a sense, this can be seen as a financial incentive to implement energy saving measures as well.

Interviewees mentioned the need for financial incentives. Tax reduction was mentioned most often. Some do mention the need for enforcing regulations and penalties in case a company does not comply with the regulation. But rewarding the leaders is mentioned as well. Since leaders can only be identified through monitoring, therefore there should be a good reporting mechanism in the programme. When targets are not reached, industries should pay back part of the financial incentive.

5.4.7 Voluntary Agreements with Industry

Voluntary agreements (VA) are tailor-made negotiated covenants between public authorities and individual firms, or groups of firms, which include targets for actions aimed at improving energy efficiency, or reducing greenhouse gas emissions, and which may define rewards, tax rebates and penalties. Voluntary agreements focus often on *high energy consuming sectors or companies. VA are often combined with Energy management systems, audit programs and motor policies (EMSA, 2014b).*

In Indonesia, voluntary energy savings and conservation measures have been communicated with energy intensive industries such as the fertilizer, cement, pulp and paper and steel industries (APERC, 2012; UNIDO, 2008). The experience from interviewees suggested that these processes had been slow, particularly in reference to the cement industry in Indonesia which had spent many years coming to agreement on a set of voluntary targets for efficiency improvement. At the same time, that experience shows that such agreements may be possible with the right stakeholders and combination of incentives and regulations.

Combination Voluntary Agreements, Energy Management and Energy Audits

In the Netherlands, there is 25 years of experience with Voluntary Agreements (VA) between the government and energy intensive industrial sectors. Most companies are a member of an industrial association. Association are an important intermediary for VA's. (Vermeeren, 2014) gives a good impression of this programme and explains that Energy Management and Energy Audits are important policy tools within the programme[19]. It states that 70% of the total industrial energy consumption is related to a VA. The government provides a website[20] as a starting point for VA's, including information on financial support, contact person each industrial subsector, practical examples, etc. (RVO, 2015).

The voluntary agreements have been negotiated between sector organizations, ministries and competent authorities. Although stated 'voluntary', the agreements are by no means without obligations. Several roles for the associations and enterprises are given. The presentations states that '*Energy Management integrates all and guarantees continuous improvement'.*

Energy audits are carried out as part of an energy management system. During an audit, energy consumption is divided in building, industrial operations (installations) and includes transportation.

At the Motor Summit of 2012[21], Energy Management is treated in combination with specific Electric Motor Driven Systems (EMDS) (Werkhoven et al, 2012). The VA's in the Netherlands are taken as an example. It explains that EMDS were given special attention for compliance with ISO50001 and to check on issues as consumption analysis, maintenance and overhaul and procurement and design. One of the conclusions is that *'the ISO 50001 standard in itself seems to have good starting points for applying efficient EMDS'*

[19] http://iet.jrc.ec.europa.eu/energyefficiency/sites/energyefficiency/files/files/documents/events/nl_-_energy_audits_madrid_20032014.pdf

[20] http://www.rvo.nl/subsidies-regelingen/meerjarenafspraken-energie-efficiency

[21] http://www.motorsummit.ch/data/files/MS_2012/presentation/ms12_van_werkhoven_update.pdf

5.5 Collect information and data on the market

The collection of adequate data is a vital step towards assessing the potential impact of the policy options and their cost-effectiveness and is part of the evidence needed to secure the necessary support for new policies. Information on the market and on the performance of motor components and systems may be gathered from industry associations, major industry partners, published data, import/export figures or it may be available for purchase from commercial market research companies. It is usual for a number of sources to be used to gain an overall picture, providing an adequate basis to estimate the size of the market and its attributes. From this data, a "business as usual" scenario can be forecast, against which the impact of future policies will be measured (EMSA, 2014b).

To a large degree, the information presented in this report represents this step in the development of a policy framework. Data has been collected from multiple sources and stakeholders, analyzed and checked for internal consistency. In chapter 3 we have discussed many quantitative aspects. This Section adds some relevant more qualitative aspects.

The 'big three'
In Indonesia, there are three large electric motor companies, Tatung, Teco and ABB. In the past, all three manufactured motors in Indonesia. At the moment, only Teco has a small production plant, see Sections 3.3 and 3.4 as well. The remaining motors are imported from their counterparts in other countries.

Tatung does not sell motors to retailers, but to exclusive dealers. Tatung target market in Indonesia is dominated by the industry. Tatung's major customers in terms of industrial subsectors are [Paper and pulp] , [Textile] and [Mining industries].

Teco percentage split by type of industry is as following (JICA & PT.EMI, 2009):
- Pump making industry : 20%
- Agriculture industry : 10%
- Textile industry : 10 %
- Others (various incl. retail) : 60%

This makes the pump making industry Teco's main market. As we know from chapter 3, electric motors combined with pumps are an important device with a large savings potential, especially in combination with VSD's. The main customers of **ABB** come from the [Pulp & paper], [Mining] and [Chemical] industries.

Supplement to priority table
In **Table 10** of Section 4, we had identified the top-4 industrial subsectors as a priority for our programme. We concluded that the [Cement and non-metallic] and [Iron and Steel] industry were our main focus, followed by the [Textile] and the [Food, Beverage, and Tobacco] industries. In **Table 14** this information has been repeated in columns 2 and 3. In column 4, we have added the above findings. This column tells us which company mainly delivers electric motors to each subsector. If our gathered information is correct, then we can conclude that from our top-4 subsectors, only the [Textile]

industry receives the bulk of electric motors from Indonesia's largest suppliers, which probably will be at level IE1. This implicates that the remaining priority industries receive motors from either smaller retail companies and/or through international orders. Possibly this includes a significant share of low quality IE0 motors from China.

Table 14: Electric motor delivering company added to **Table 10**

			1	2	3	4
	ISIC division	**Medium and large size enterprises**	**Electricity consumption GWh**	**Electricity savings potential electric motors GWh**	**Electricity savings potential pumps, fans, compressors**	**Electric motor delivering company**
		Year:	2025	2025	2025	
1	10+11+12	Food, Beverage, and Tobacco	11,191	744	449	
2	13+14+15	Textile, leather, shoe, sandal	11,899	791	292	Tatung, Teco
3	16+31	Wood, furniture, and forestry	849	57	21	
4	17+18	Pulp & paper, print industry	3,965	204	188	Tatung, Teco, ABB
5	20+21+22	Chemical, fertilizer & rubber industry	12,799	223	158	ABB
6	23	Cement and non-metallic	6,996	1,409	634	
7	24+25	Iron and Steel industry	4,600	667	246	
8	28+29+30+33	Machinery industry	7,050	471	177	
9	26+27+32	Other industry	5,567	207	128	
		Total industry sector	**64,916**	**4,774**	**2,293**	
10		Commercial sector	128,056	4,499	3,712	Teco (retail)
		Total industry plus commercial	**192,972**	**9,273**	**6,004**	

5.6 Identify existing policies or activities

Policies to encourage greater efficiency in motor systems may sit within a wider policy portfolio in government. For example, they may fit with policies to encourage industry development. This suggests that a review of existing government policies will need to be wide-ranging in order to identify policies that may already have an influence on the motor systems market. (EMSA, 2014b).

In Indonesia, there are, or have been, several programs that stimulate energy efficiency in the industrial and commercial sector. By definition, these programs also target electric motor driven systems. Some of these were set up in cooperation with international organizations. In the Section 5.4, some of these have been mentioned and some others are described below.

1. Asian Development Bank (ADB)

   ADB promotes energy efficiency in Indonesia, which included the industrial and commercial sector. ADB has invested over $27 billion in Indonesia since 1966 from which 13% for energy conservation lending under the 'Clean

Energy Programming'. ADB supports clean energy deployment through its public (loans and guarantees) and private (loans, equity and guarantees) sector arms (Tharakan, 2014).

Within this programme, the Indonesian Export Financing Agency (LPEI), in collaboration with the Asian Development Bank (ADB), launched 'Energy Efficiency Project Finance Program'. The first companies to receive funding operate in the food sector. According to (The Jakarta Post, 2014), ADB wants to continue to strengthen the program in the hope that it will attract other firms in energy-intensive sectors, such as textiles, cement and steel. The current status of the program is not known to us.

2. GIZ has been working in Indonesia since 1975 (GIZ, 2015a) and their current programme includes various energy efficiency programs. PAKLIM, which stands for 'Policy advice for environment and climate change', is very much relevant for our project (GIZ, 2015b). Some of the projects we have discussed:
   - Together with Adidas, GIZ had a program for 2 years to stimulate energy reduction in the apparel and footwear industry (GIZ, 2013). Workshops have been conducted with different target groups ('Energy Efficiency Awareness'), but not so extensive as ISO50001.
   - After this project, a program started with the focus on electric motors in 'food and beverage', 'textile' and 'paper and pulp' industry (GIZ, 2014). Workshops on electric motors have been conducted, with an expert from Siemens, with different target groups. Due to the importance of the outcomes of these workshops, the suggested conclusions and recommendations have been added to Appendix R. Again, the same barriers have been identified, related to awareness and information, motor management and financial incentives. One recommendation was to introduce a standard for motor rewinding companies.
   - GIZ previously worked closely with the cement industry and MoI on the topic of using recycled material in their processes. They also worked with cement association on trying to make Voluntary Partnership Agreements in order to get CDM credits. They found that firms may prefer the certainty of regulation compared to voluntary agreements.

3. The Government (ESDM) collected from several sources 800 energy audits, done during 2004 – 2012. These were mainly performed as 'walkthrough' audits, where possible efficiency improvements are pointed out and estimated. This relates to the in Section 5.4 mentioned obligation for high energy consumer (min 6000 TOE/year) to conduct energy audits periodically and appoint energy managers. The government is intending to lower that level to 4500 TOE/year. These audits form the basis for the ESDM's *Investment opportunity book* where they took, following several selection criteria, the 47 largest companies and reported all the possible improvements and how much investment would be required. No follow-up has been done yet. UNIDO supported the launch of the book by offering training to banks on energy efficiency lending.

4.

Extending the priority table

In **Table 10** of Section 4 we had identified the top-4 industrial subsectors as a priority for our programme. In **Table 14**, this table was supplemented with the main electric motor suppliers. In **Table 15**, we extend the table with findings on energy efficiency initiatives that have been discussed above. Note that this table not necessarily is complete.

With this overview we can conclude that a number of relevant activities have already been carried out. The challenge now is to make sure that this experience is utilized within our electric motor project. More specifically, within our priority subsector (in yellow in **Table 15**), the [Iron and Steel] industry, seems to have received less attention, whereas the [Textile] and [Cement] industry received most attention.

Table 15: EE activities by subsector, completing **Table 10**

			1	2	3	4	5	6	7	8	9
	ISIC division	**Medium and large size enterprises**	**Electricity savings potential electric motors GWh**	**Electric motor delivering company**	**MEPS**	**Voluntary agreements**	**Energy management**	**Energy Audits**	**Motor Policy**	**Financial incentives**	**Awareness and information**
		Year:	2025								
1	10+11+12	Food, Beverage, and Tobacco	744				UNIDO: ISO 50001 GIZ: CSR/EMS				
2	13+14+15	Textile, leather, shoe, sandal	791	Tatung, Teco			UNIDO: ISO 50001 GIZ: CSR/EMS	GIZ: introduction of green technology			
3	16+31	Wood, furniture, and forestry	57								
4	17+18	Pulp & paper, print industry	204	Tatung, Teco, ABB		Gov: Pulp & Paper	UNIDO: ISO 50001 GIZ: CSR/EMS	GIZ: GHG Emission Calculation	GIZ: Inventory		GIZ: CSR based on ISO 26000
5	20+21+22	Chemical, fertilizer & rubber industry	223	ABB		Gov: Fertilizer	UNIDO: ISO 50001				
6	23	Cement and non-metallic	1,409			Gov, GIZ: Cement	GIZ: technical guideline CO2 calculation & NAMA				GIZ: technical study AFR/RDF
7	24+25	Iron and Steel industry	667			Gov: Steel					
8	28+29+30+33	Machinery industry	471								
9	26+27+32	Other industry	207								
		Total industry sector	**4,774**				Gov: above 6000 TOE/year GIZ: training Electric Motor 2016.	Gov: 1000 walkthrough GIZ: training Electric Motor 2016.		Gov: funding to improve efficiency, remove subsidies GIZ: PAKLIM	ADB: promoting energy efficiency in Indonesia
10		Commercial sector	4,499	Teco (retail)			GIZ: training Electric Motor 2016.				ADB: promoting energy efficiency
		Total industry plus commercial	**9,273**		Gov, incl; test lab			Gov: certificate		Gov: tax exemption, fiscal incentives	Gov: 'National Energy Efficiency Movement' Gov: Clearing House of Energy Conservation

5.7 Second phase of the project

Until now the project has been developing the evidence base and network of stakeholders that will be used for policy design and feedback. The second phase of the project will include elements of the following topics (EMSA, 2014b):

Assess policy options
Each policy option should be assessed according to its ability to achieve the identified objectives and to address the particular barrier identified in Section 5.3. To do this will require an understanding of how each policy will be implemented and an estimation of the likely impact and cost of each policy measure. Costs and benefits may need to be apportioned to various stakeholders impacted by the policy measure, as well as on a societal basis.

Assess risks to achieving the desired policy objectives.
An assessment of the risk that a policy, when implemented, may not achieve its objectives is a vital part of the development cycle and a necessary component of most approval processes.

Consult with stakeholders
Consultation with stakeholders is part of the process of seeking further engagement in the policy development process and will help to gain greater commitment to the final result. Often, the early involvement of stakeholders in policy development can identify partners and initiatives that will improve the implementation of a certain policy.

Proposal for approval, Implementation.
The presentation of final proposals for approval by the relevant authorities will build on the information and analysis undertaken throughout the previous steps.

After these preparatory activities, the final phase will consists out of:

Implementation process
While not part of the policy development process, consideration on how policies will be implemented must be part of the policy design process to ensure that implementation is feasible and in order to understand the costs involved. Following approval, a detailed implementation strategy should be developed alongside any partners that will assist.

Evaluation & Feedback
It is important to plan for the evaluation of any policy efforts, both to allow Indonesia to monitor and report and on any GHG emissions reductions that can be attributed to these efforts, as well as to understand the savings/benefits that have been achieved. Evaluation of performance over time also allows policies to be revised as needed in order to ensure that outcomes are being achieved cost effectively.

The above findings will be developed in consultation with ESDM as the eventual implementing party of any policy framework. The results will be delivered in the form of a detailed proposal that includes the evidence base for taking action, describes policy measures and their costs, and an approach to monitoring and reporting outcomes.

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Appendix A.

Search for the Indonesian present market share by IE-class capacity

There is not much data available on the present Indonesian motor stock. Appendix A reflects our thinking process that has led to our assumption of the present market share by IE-class.

A more comprehensive market survey on industrial electric motors was last done in 2009 (JICA & PT.EMI, 2009). If we analyse the efficiency of the 560 motors evaluated in this survey, the outcome would be that about 50% are already rated as 'high efficiency'. In terms of international classes, this would be 'at least class IE2', as shown in chapter 1. But it is important to note that this survey only included motors from the major brands ABB, Tatung and Teco. A survey that apparently includes other brand names as well can be found in (PT Solvindo & ICA, 2013). According to this survey, only 22% of the 60 evaluated electric motors are rated as high efficiency. A tentative conclusion would be that motors that are purchased from brand names other than the 'big three', probably will have efficiencies below what is preferable.

Anecdotally, it is often heard that many low efficiency motors are imported from China and other countries in the region. According to that later study, in 2013 around 38% of all imported electric motors came from China, followed by Germany (11%), Japan (10%) and Malaysia (9%). If we would know the IE-classes of these imported motors, we would get a better understanding of the market share in Indonesia.

According to (Chee Jin, 2015), China produced 20,5 million electric motors in 2013, from which 62% are IE0 and IE1 motors. Important to understand is that splitting these numbers further into IE1 and IE0 is not possible at the moment, due to lack of additional information. China exported in total 9% (1,8 million pieces). The IE0 & IE1 share in the exported motors is 23%. See the below table.

Table 16: Production, domestic sale and export figures small and medium size motors China 2013 according to ICASEA

IE class	Production (number)	% share production (number)	Domestic sale (number)	% domestic sale (number)	Export (number)	% share export (number)
IE4	38,966	0.2%	1,858	0.01%	37,108	2.0%
IE3	1,645,315	8%	901,468	5%	743,846	40%
IE2	6,140,891	30%	5,494,869	29%	646,022	35%
IE0 & IE1	12,749,641	62%	12,333,021	66%	416,620	23%
Total	20,574,813	100%	18,731,217	100%	1,843,596	100%

China / China Energy Label		
regulation / standard	GB25958-2010	GB18613-2012
voltage	up to 690 V	up to 1000V
frequency	50 Hz	
speed	2,4 & 6 poles	
minimum efficiency	since 1.7.2011 low-power three-phase asynchronous motors 2W–2.2kW (identical to IE2 0.75kW -->)	since 1.9.2008 (revised 2012) update of GB18613-2006 and GB/T1032 0.75kW–375kW (identical to IE2)
main exclusions - marine - brake motors - motors completely integrated into a machine - conical rotor motors for electrical hoist and construction machinery - motors with electro-magnetic braking inside - motors with a duty type other than S1 or S3 with a rated cyclic duration factor of 80% or higher - wound-rotor induction motors - two-/multispeed motors - VSD motors		
testing method	under GB/T1032 the testing method is identical to IEC 60034-2-1 and the grades are in line with the classes in IEC 60034-30 (IE2/IE3) and IEC 60034-31 (IE4)	
future:	1.9.2016: 7.5kW–375kW (IE3) 1.9.2017: 0.75kW–375kW (IE3)	

In China MEPS for small and medium three-phase asynchronous motors have been in place since 2002. The standard was updated in 2006, and in 2012 it was harmonized with IEC Standards. At the same time the MEPS were increased from IE1 to IE2 (IEC, 2015). Next year, they will shift further up to IE3 , as shown in the lower part of the overview on the left (ABB, 2012a). This means that in theory, in 2013 stand-alone IE0 & IE1 electric motors could not enter the domestic market of China. With this reason we think that the 12,3 million IE0 & IE1 electric motors of **Table 16** mentioned under 'domestic sale' are part of the 'main exclusions' as mentioned on the left. They are used in e.g. 'packed machines', on the left described as 'motors completely integrated into a machine', such as household fans. MEPS often do not target packed machines. The remaining 416 thousand (stand-alone) IE0 & IE1 electric motors were probably solely produced for the export market. See the source of the left overview for similar information for other countries.

From (PT Solvindo & ICA, 2013), we estimate that in 2013 around 500 thousand electric motors have been imported into Indonesia. If 38% of these came from China (190 thousand), and we assume that these were mostly IE0 & IE1 motors, then we can conclude very cautious that 46% of China's exported low and standard efficiency motors ends up in Indonesia.

In other words, one can say that China's export of these lower efficiency motors significantly depends on Indonesia. We should take this into account when implementing and enforcing MEPS for electric motors in Indonesia. Bilateral communication with China could be part of the strategy.

An additional clue of the Indonesian IE-class market share comes from a small survey that we have conducted ourselves. Consider the nameplate below of a random electric motor in Indonesia.

Figure 24: Name plate of an random electric motor Indonesia

This is an electric motor that provides an output capacity P_{out} of 45 kW. The input capacity can be calculated with the following formula:

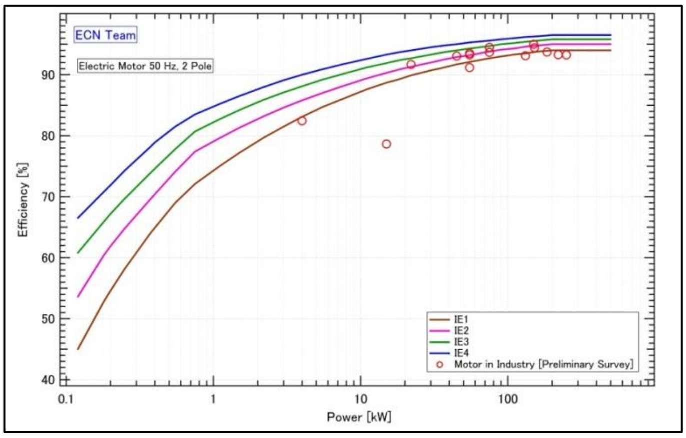
$$P_{in}(kW) = \frac{Voltage\ (V) * Current\ (A) * PowerFactor\ (PF\_\cos\varphi\ ) *\ \sqrt{3}}{1000}$$

The power factor is crucial for the efficiency, the higher PF, the higher the efficiency. For this electric motor the power input P_{in} can be calculated as:

$$P_{in} = \frac{380 * 83.5 * 0.88 *\ \sqrt{3}}{1000} = 48{,}4\ kW$$

The efficiency of this electric motor would therefore be $P_{out\,/}P_{in}$ = 45/48,4 = 93,0 %.

- Note that this coincides with the 93,0% that is mentioned on the name plate
- Note that this can be considered as a high efficiency electric motor, class IE2, according to the **Figure 3**



In this way, we have calculated the related IE-class of 15 randomly selected electric motors in Indonesia. From this very small survey, we could find that only 1 motor performs far below IE1 and 5 just very slightly below IE1, 3 motors perform at IE1, and 7 perform at IE2. Note that IE1 means a performance starting at the line representing IE1 and including the area until the line has been reached that represents IE2.

Altogether, based on both our own small sample and previous larger surveys, we can conclude that most of Indonesian electric motors are already at the level of IE1.

The present estimated market share based on our calculations and assumptions is presented in the below table.

Copy of **Table 1**: Present market share electric motors Indonesia by IE-class

IE class	% market share (units until 0.75 kW)	% market share (units between 0.75 and 45 kW)	% market share (units above 45 kW)	% market share (all units)
IE4	0%	0.4%	0.8%	0.3%
IE3	0%	2%	5%	2%
IE2	0%	5%	10%	3%
IE1	50%	59%	68%	56%
IE0	50%	34%	17%	39%
Total	100%	100%	100%	100%

Appendix B.

Search for the Indonesian present market share by motor size

With the data collected and produced so far, we can make a more educated guess of the Indonesian motor market share by motor size and the related electricity consumption. The naming convention based on motor size follows that introduced in Section 2.3:

- Small size motors: less than 0.75 kW
- Medium size motors: from 0.75 kW up to 375 kW
- Large size motors: above 375 kW, up to e.g. 100.000 kW

As explained in chapter 2, this project focuses mainly on the medium size motors, followed by the large size motors. The total number of medium size and large size motors can be predicted with import data from (PT Solvindo & ICA, 2013), combined with assumptions for real lifetime expectancies (Appendix C) and average running hours a year (Waide & Brunner, 2011). To get a complete picture of the market share by motor size, we try to estimate the market size of small size motors as well, following this strategy:

In **Table 3**, we have estimated around 3 million medium and large size electric motors to be present in Indonesia. According to (Waide & Brunner, 2011), as a world-average, there are a factor 8.7 more small electric motors, compared to the total sum of medium and large size motors. In Indonesia this factor could even be higher. As an example, Indonesia will have more household fans then an average country in this world. This could cautiously be confirmed by (Waide & Brunner, 2011); Indonesia consumes 1.5 times more electricity in the residential sector for electric motors. These are mainly the small ones. Combined (1.5*8.7), this gives a factor 13 times more small electric motors in Indonesian, compared to the middle and large size motors, which would almost be (13*3 million) 40 million small sizer motors. In total, including medium and large size electric motors, this would give 43 million pieces of electric motors.

Note that this is not a very accurate nor particularly important conclusion, but it adds to getting a better understanding of the Indonesian electric motor market in general. The results of this exercise are summarized in the table below, together with a comparison for world-figures (taken from **Figure 1**).

By incorporating the efficiency data of **Figure 3** for the distinguished IE-classes by motor capacity, we can calculate the total electricity consumption by electric motor size.

Copy of **Table 2:** World and Indonesian electric motor market share by size

	small size motors	medium size motors	large size motors	total medium & large motors	total motors
World: total running stock 2009 mln pieces	2,000	230	0.6	231	2,231
Indonesia: total running stock 2014 mln pieces	40	3.1	0.001	3.1	43
World electricity demand 2009 (TWh/yr)	632	4,676	1,611	6,287	6,919
Indonesia electricity demand 2014 (GWh/yr)	12,549	66,136	10,830	76,966	89,515
The above numbers turned into a percentage					
World: % of total running stock	90%	10%	0.03%	10%	100%
Indonesia: % of total running stock	93%	7%	0.002%	7%	100%
World: % of total electricity demand	9%	68%	23%	91%	100%
Indonesia: % of total electricity demand	14%	74%	12%	86%	100%

Appendix C.

Efficiency by capacity and IE-class

kW output	Hp	% eff IE0	% eff IE1	% eff IE2	% eff IE3	% eff IE4	Operating time (years)
0.37	0.50	57.84	66.3	76.0	79.3	80.95	10
0.55	0.74	61.55	69.2	77.8	80.9	82.5	10
0.75	1	65.31	72.1	79.6	82.5	84.0	10
1.1	1	69.10	75.0	81.4	84.1	85.5	20
1.5	2	71.98	77.2	82.8	85.3	86.6	20
2.2	3	75.35	79.7	84.3	86.7	87.9	20
3	4	77.69	81.51	85.53	87.71	88.81	20
3.7	5	79.74	83.1	86.6	88.6	89.6	20
4	5	80.08	83.37	86.78	88.77	89.76	20
5.5	7	81.80	84.7	87.7	89.6	90.6	20
7.5	10	83.38	86.0	88.7	90.4	91.3	20
9	12	84.27	86.69	89.17	90.83	91.66	20
11	15	85.45	87.6	89.8	91.4	92.2	20
15	20	86.84	88.7	90.6	92.1	92.9	20
18.5	25	87.44	89.3	91.2	92.6	93.3	20
22	30	88.23	89.9	91.6	93.0	93.7	20
30	40	89.13	90.7	92.3	93.6	94.3	20
37	50	89.72	91.2	92.7	93.9	94.5	20
45	60	90.32	91.7	93.1	94.2	94.8	30
55	74	90.72	92.1	93.5	94.6	95.2	30
75	101	91.42	92.7	94.0	95.0	95.5	30
90	121	91.82	93.0	94.2	95.2	95.7	30
110	148	92.12	93.3	94.5	95.4	95.9	30
132	177	92.32	93.5	94.7	95.6	96.1	30
160	215	92.71	93.8	94.9	95.8	96.3	30
200	268	92.91	94.0	95.1	96.0	96.5	30
250	335	92.91	94.0	95.1	96.0	96.5	30
280	375	92.91	94.00	95.10	96.00	96.45	30
315	422	92.91	94.00	95.10	96.00	96.45	30
330	443	92.91	94.0	95.1	96.0	96.5	30
355	476	92.91	94.0	95.1	96.0	96.5	30
375	503	92.91	94.00	95.10	96.00	96.45	30
400	536	92.91	94.00	95.10	96.00	96.45	30
450	603	92.91	94.00	95.10	96.00	96.45	30
500	671	92.91	94.00	95.10	96.00	96.45	30
560	751	92.91	94.00	95.10	96.00	96.45	30
930	1,247	92.91	94.00	95.10	96.00	96.45	30
5000	6,705	92.91	94.0	95.1	96.0	96.5	30

Appendix D.

Purchase cost (IDR) by capacity and IE-class

kW	Hp	IE0	IE1	IE2	IE3	IE4	kW	Installation costs (work days)	Installation costs labour (IDR)	Installation costs other (IDR)	Total installation costs (IDR)
0.37	0.50	446,792	891,623	1,104,396	1,215,849	1,327,302	0.37		-	0	
0.55	0.74	664,151	1,325,385	1,641,670	1,807,343	1,973,016	0.55		-	0	
0.75	1	680,000	1,400,691	1,641,670	1,807,343	1,973,016	0.75		-	0	
1.1	1	800,000	1,596,487	1,882,649	2,108,567	2,334,485	1.1		-	0	
1.5	2	931,174	1,822,404	2,153,751	2,409,791	2,665,831	1.5		-	0	
2.2	3	1,256,015	2,409,791	2,846,566	3,253,218	3,659,870	2.2		-	0	
3	4	1,449,966	2,726,076	3,208,034	3,659,870	4,111,706	3		-	0	
3.7	5	1,709,685	3,148,543	3,719,738	4,095,892	4,472,045	3.7		-	0	
4	5	1,848,308	3,403,830	4,021,339	4,427,991	4,834,643	4		-	0	
5.5	7	2,455,782	4,427,991	5,226,234	5,753,376	6,280,518	5.5		-	0	
7.5	10	2,884,920	5,090,683	6,009,416	6,611,864	7,214,312	7.5		-	0	
9	12	3,394,284	5,858,804	7,042,745	7,748,785	8,454,824	9		-	0	
11	15	4,507,000	7,605,903	8,976,471	10,347,040	11,717,609	11	1	500,000	2,800,000	1,060,000
15	20	5,158,825	8,675,248	10,226,550	11,130,222	12,033,894	15	1	500,000	2,800,000	1,060,000
18.5	25	6,543,305	10,964,549	12,937,565	14,082,216	15,226,867	18.5	1	500,000	2,800,000	1,060,000
22	30	7,026,617	11,732,670	13,841,237	15,392,540	16,943,843	22	1	500,000	2,800,000	1,060,000
30	40	9,550,140	15,889,559	18,299,350	18,856,614	19,413,879	30	1	500,000	2,800,000	1,060,000
37	50	11,019,760	18,269,228	24,067,787	24,097,910	24,128,032	37	1	500,000	2,800,000	1,060,000
45	60	14,013,442	23,149,055	26,658,313	26,688,435	26,718,557	45	1	500,000	2,800,000	1,060,000
55	74	16,117,000	26,432,395	30,438,672	34,490,133	38,541,594	55	2	850,000	2,800,000	1,410,000
75	101	20,994,382	35,951,069	41,418,282	43,511,788	45,605,294	75	2	850,000	2,800,000	1,410,000
90	121	22,818,000	40,725,468	46,900,557	47,533,127	48,165,697	90	2	850,000	2,800,000	1,410,000
110	148	38,704,000	64,612,521	67,097,618	67,383,780	67,669,943	110	3	1,200,000	7,900,000	2,780,000
132	177	44,593,274	69,522,470	72,188,301	73,543,808	74,899,316	132	3	1,200,000	7,900,000	2,780,000
160	215	51,671,000	74,854,132	77,730,820	83,710,114	89,689,408	160	3	1,200,000	7,900,000	2,780,000
200	268	59,837,774	84,598,725	87,851,942	88,710,430	89,568,919	200	3	1,200,000	7,900,000	2,780,000
250	335	98,038,936	135,189,274	137,689,432	146,003,211	154,316,990	250	3	1,200,000	7,900,000	2,780,000
280	375	107,563,329	144,572,398	147,253,290	156,124,333	164,995,376	280	3	1,200,000	7,900,000	2,780,000
315	422	113,844,692	149,045,572	151,801,771	160,958,976	170,116,182	315	3	1,200,000	7,900,000	2,780,000
330	443	116,204,832	148,083,777	151,681,917	160,838,275	169,994,632	330	3	1,200,000	7,900,000	2,780,000
355	476	125,008,228	159,302,245	163,172,972	173,022,992	182,873,013	355	3	1,200,000	7,900,000	2,780,000
375	503	218,450,795	270,762,608	277,341,600	284,080,447	290,819,295	375	4	1,550,000	10,200,000	3,590,000
400	536	233,014,181	288,813,449	295,831,040	303,019,144	310,207,248	400	4	1,550,000	10,200,000	3,590,000
450	603	253,149,489	304,943,987	312,353,518	319,943,085	327,532,653	450	4	1,550,000	10,200,000	3,590,000
500	671	270,004,403	315,833,230	323,507,348	331,367,931	339,228,514	500	4	1,550,000	10,200,000	3,590,000
560	751	286,196,262	324,794,641	332,686,502	340,770,121	348,853,739	560	4	1,550,000	10,200,000	3,590,000
930	1,247	295,267,855	324,794,641	332,686,502	340,770,121	348,853,739	930	4	1,550,000	10,200,000	3,590,000
5000	6,705	#############	#############	#############	#############	#############	5000	6	2,325,000	15,300,000	5,385,000

Assumptions costs:

1. An installation group of engineers, always has 1 senior engineer (Rp 500.000/h), and possibly junior engineers (Rp 300.000), in the table mentioned under 'installation costs labour'
2. Only 20% of motors need external employees, in the table mentioned under 'installation costs other':
   - For work out of Jakarta province, transportation, accommodation is needed. We assume an average flight cost of Rp 2,000,000 (Java island).
   - Accommodation: Rp 500.0000/ person/day
   - Food and beverages: Rp 300,000

Appendix E.

Pay-back period; mid-life replacement, or ‘new placement’

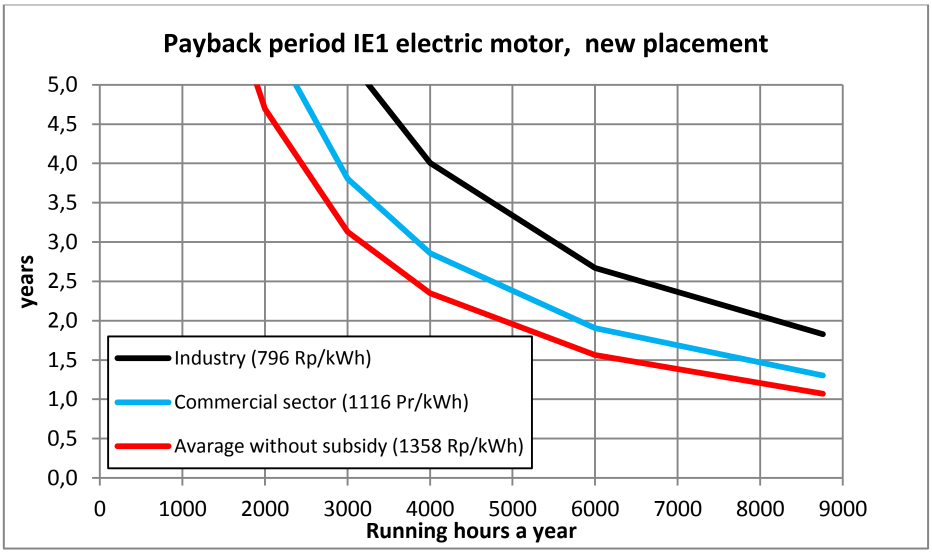
Imagine an existing running IE0 electric motor not necessarily needs to be changed. It could be halfway it’s technical lifetime, 6 years old, and still has at least 6 more years to go. What to do now? **Figure 25** gives an answer to that question. In this figure, the simple payback period is given for a IE1 electric 1.1 kW motor, as a new placement. Now, the payback period is based on the *total* investment of the IE1 electric motor, instead of only the *additional* costs compared to the IE0 electric motor. But we have to add the installation costs mentioned in Appendix D, since this choice was from a technical point of view not necessary. The installation costs are however divided by the expected technical lifetime, which make them almost negligible, just like the maintenance costs.
This is really the bottom line in terms of payback period, since we are not even taking into account the remaining value of the existing motor which has not yet reached the end of its technical lifetime. Nor do we take into account that the installation costs are also taking place earlier than strictly required.

From **Figure 25** we can conclude, that the acceptable payback period of three years is now reached at a bit more as double the amount of running hours a year, compared to **Figure 16** :

- Industrial sector: 5500 hours a year
- commercial sector: 3800 hours a year
- when subsidies would be removed: 3000 hours a year

This is simply due to the fact that the IE1 motor is about double the price of a IE0 motor.

Figure 25: Simple payback period new placement, IE1



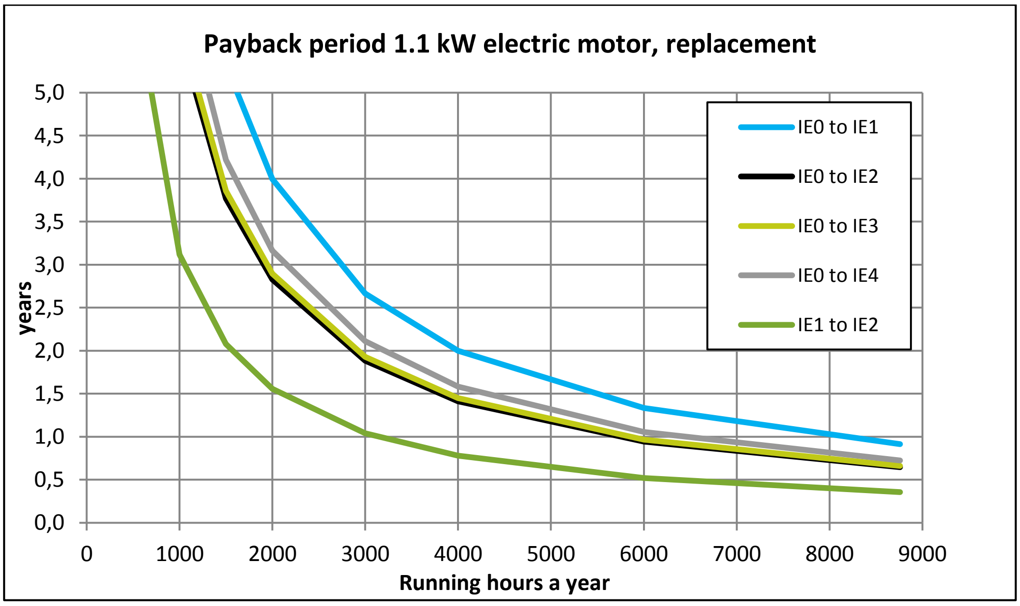
Appendix F.

Pay-back period: replacing IE0 by IE2

A 1.1 kW IE1 motor is double the price of a IE0 motor. An IE2 motor is just 18% more expensive compared to a IE1 electric motor. The efficiency difference in both situation is expected to be about the same; about 6%. This means that the pay-back period for replacing an IE1 for a IE2 is less, compared to the pay-back period of replacing an IE0 for an IE1 motor (Section 3.6). Surprisingly, but simply as a consequence of this fact, replacing an IE0 for a IE2 motor, will have a pay-back period somewhere in the middle of the previous two examples. This means that it is financially more attractive to replace a IE0 by an IE2, instead of by an IE1 motor. It is still more attractive to replace an IE0 motor, by an IE3 or IE4 class motor, instead of by an IE1 motor. **Figure 26** shows this into more details. This is simply related to the fact that the purchase costs are relatively so little, when considering the technical life time of the motor.

Even when the efficiency of the 'unknown' IE0 electric motor would have a better efficiency then estimated in this report, there still will be plenty of situations whereby it will be more attractive to choose an IE2 (or even an IE3 or IE4), instead of an IE1 motor.

Figure 26: Pay-back period for a 1.1 kW electric motor, different IE-classes replacements



Appendix G.

Cumulative savings towards 2035

Figure 27 gives the cumulative effect of **Figure 20** for electricity savings over time.

Figure 27: MEPS IE-classes and EMDS; development of electricity consumption, cumulative effect

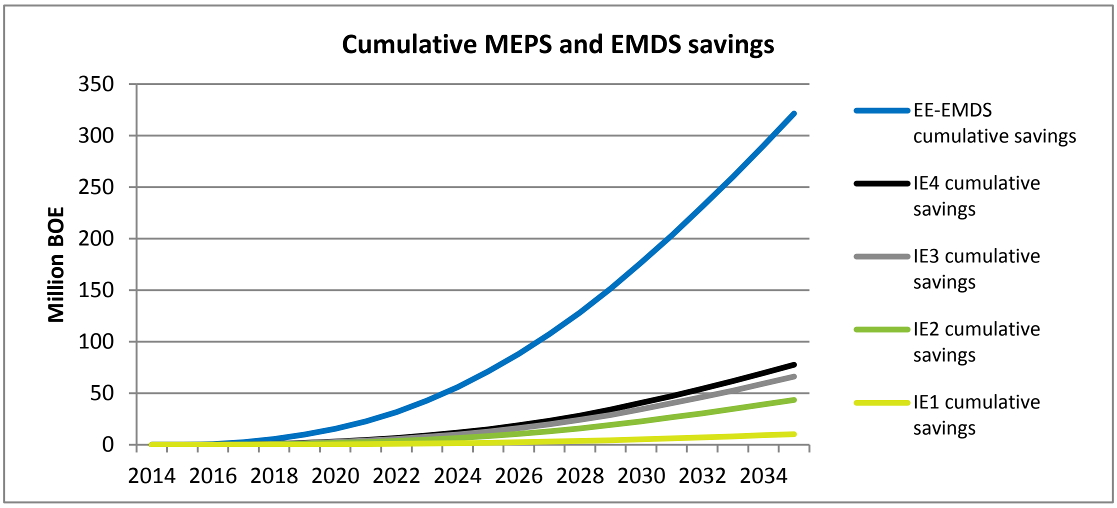
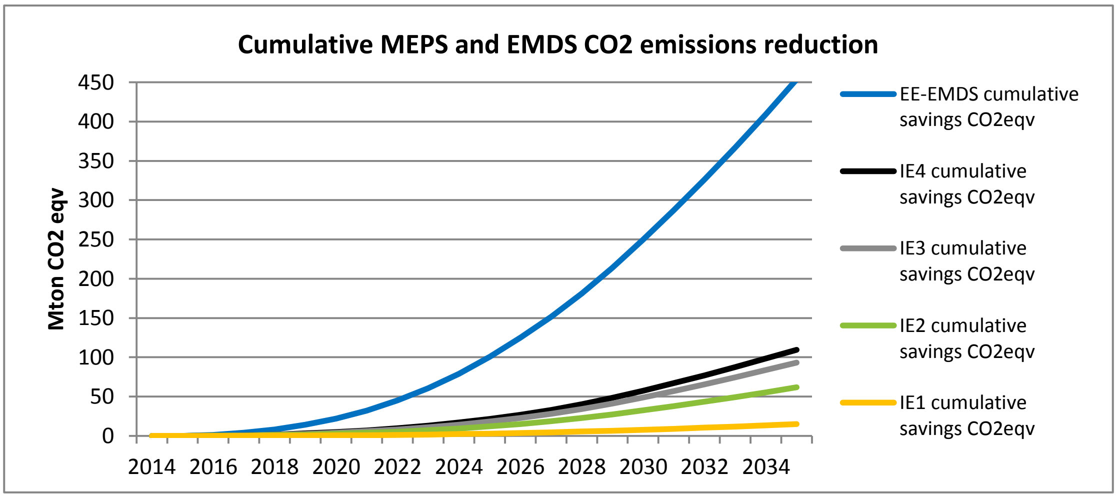


Figure 28 gives the related cumulative effect of **Figure 21** for avoided CO2 emissions.

Figure 28: MEPS IE-classes and EMDS; related CO2 emissions; cumulative effect



Appendix H.

Cumulative and yearly average effects of MEPS IE-targets and EMDS in USD

Motor efficiency class	International coding	Market share and savings for chosen MEPS IE-class: Present share	MEPS on IE1	MEPS on IE2	MEPS on IE3	MEPS on IE4	MEPS and EE-EMDS
Super premium	IE4	0.3%	0.3%	0.3%	0.3%	100%	100%
Premium	IE3	1.5%	2%	2%	100%	0%	0%
High	IE2	3.3%	3%	98%	0%	0%	0%
Standard	IE1	56.1%	95%	0%	0%	0%	0%
Below Standard	IE0	38.7%	0%	0%	0%	0%	0%
	Total share:	100%	100%	100%	100%	100%	100%
	% sector savings MEPS IE-target	0%	0.7%	2.9%	4.4%	5.1%	20%
Cumulative results 2015-2035 (20 years)							
	Cumulative savings sector 2035 (mln BOE)	-	10	44	66	78	321
	Cumulative savings sector 2035 (TWh)	-	17	71	108	126	523
	Cumulative avoided CO2 emissions sector 2035 (Mton)	-	15	62	93	110	454
	Cumulative savings sector 2035 electricity mln USD	-	1,198	4,995	7,554	8,870	36,706
	Cumulative savings governmental subsidies 2035 mln USD	-	713	2,973	4,496	5,279	21,847
Average results a year 2015-2035							
	Average yearly savings sector untill (mln BOE)	-	0.5	2.2	3.3	3.9	16.1
	Average yearly savings sector (TWh)	-	0.9	3.6	5.4	6.3	26.2
	Average yearly avoided CO2 emissions sector (Mton)	-	0.7	3.1	4.7	5.5	22.7
	Average yearly savings sector 2035 electricity mln USD	-	60	250	378	443	1,835
	Average yearly savings governmental subsidies mln USD	-	36	149	225	264	1,092

Appendix I.

Needed investment IDR and installation workforce in man-years

In Section 3.3 we have estimated the present (2014) electric motor stock in Indonesia in terms of number of motors with a certain capacity. These motors will have to be replaced the next coming 20 years. From Appendix D, we know the investment costs each motor by IE-class and the needed man-hours to install them. By combining these data, we can estimate the total investment costs and workforce needed, to replace the present stock under a MEPS programme.

Table 17 gives in the first two rows the present number of medium and large size motors and related value by IE-class. The next four rows give the costs in bln IDR when these motors are replaced through a MEPS programme at a certain IE-level. The last column gives the needed man-years to install these new electric motors. Note that the needed man-year is independent from the IE-class of the electric motor. Appendix J gives the same table in USD.

Table 17: Present number of (medium and large size) electric motors and related value by IE-class, followed by replacement costs IDR and needed man-years for a certain MEPS programme

2014	IE0	IE1	IE2	IE3	IE4	Total	Total installation costs (bln IDR)	Needed man-years installation
Present motors (number)	1,078,484	1,771,123	132,416	61,115	10,186	3,053,324		
Present value bln IDR	2,148	9,072	1,164	571	101	13,056		
MEPS IE1 replacement bln IDR	-	12,715	1,164	571	101	14,551	415	1,905
MEPS IE2 replacement bln IDR	-	-	15,644	571	101	16,316	415	1,905
MEPS IE3 replacement bln IDR	-	-	-	17,404	101	17,505	415	1,905
MEPS IE4 replacement bln IDR	-	-	-	-	18,729	18,729	415	1,905

By extrapolating[22] we project these numbers on the year 2035. Obviously we don't take into account effects as inflation.

22 We know from **Figure 18** that the electricity consumption for electric motors in the commercial and industrial sector will grow from 46 mln BOE in 2014 towards 157 mln BOE in 2035. By multiplying the numbers of **Table 17** with a growth-factor 157/46=3.4, we extrapolate towards 2035.

Table 18: Number of (medium and large size) electric motors and related value by IE-class for 2035, followed by replacement costs and needed man-years for a certain MEPS programme

2035	IE0	IE1	IE2	IE3	IE4	Total	Total installation costs (IDR)	Needed man-years installation
2035 motors BAU (number)	3,694,053	6,066,497	453,555	209,333	34,889	10,458,328		-
2035 value BAU bln IDR	7,356	31,075	3,986	1,957	346	44,720		
IE1 MEPS replacement bln IDR	-	43,552	3,986	1,957	346	49,841	1,422	6,525
IE2 MEPS replacement bln IDR	-	-	53,584	1,957	346	55,887	1,422	6,525
IE3 MEPS replacement bln IDR	-	-	-	59,614	346	59,960	1,422	6,525
IE4 MEPS replacement bln IDR	-	-	-	-	64,150	64,150	1,422	6,525

When dividing by 20 years, we get the average numbers as presented in **Table 6** in Section 3.10.

Average yearly 2014-2035	IE1	IE2	IE3	IE4	Total	Total installation costs bln (bln IDR)	Needed man-years installation
IE1 MEPS replacement bln IDR	2,177.58	199	98	17	2,492	71	326
IE2 MEPS replacement bln IDR	-	2,679	98	17	2,794	71	326
IE3 MEPS replacement bln IDR	-	-	2,980	17.28	2,997	71	326
IE4 MEPS replacement bln IDR	-	-	-	3,207	3,207	71	326

The same tables in USD are added to Appendix J.

Appendix J.

Needed investment USD and workforce in man-year for MEPS

Table 19: Present number of motors and related value by IE-class, followed by replacement costs mln USD and needed man-years for a certain MEPS programme

2014	IE0	IE1	IE2	IE3	IE4	Total	Total installation costs bln (mln USD)	Needed man-years installation
Present motors (number)	1,078,484	1,771,123	132,416	61,115	10,186	3,053,324		
Present value mln USD	161	680	87	43	8	978		
IE1 MEPS replacement mln USD	-	953	87	43	8	1,090	31	1,905
IE2 MEPS replacement mln USD	-	-	1,172	43	8	1,222	31	1,905
IE3 MEPS replacement mln USD	-	-	-	1,304	8	1,312	31	1,905
IE4 MEPS replacement mln USD	-	-	-	-	1,403	1,403	31	1,905

Table 20: Number of motors and related value by IE-class for 2035, followed by replacement costs mln USD and needed man-years for a certain MEPS programme

2035	IE0	IE1	IE2	IE3	IE4	Total	Total installation costs bln (mln USD)	Needed man-years installation
2035 motors BAU (number)	3,694,053.45	6,066,497	453,555	209,333	34,889	10,458,328		
2035 value BAU mln USD	551	2,328	299	147	26	3,350		
IE1 MEPS replacement mln USD	-	3,263	299	147	26	3,734	107	6,525
IE2 MEPS replacement mln USD	-	-	4,015	147	26	4,187	107	6,525
IE3 MEPS replacement mln USD	-	-	-	4,466	26	4,492	107	6,525
IE4 MEPS replacement mln USD	-	-	-	-	4,806	4,806	107	6,525

When dividing by 20 years, we get the average yearly numbers of the below table.

Table 21: Yearly replacement costs (mln USD) and needed man-years for a certain MEPS programme

Average yearly 2014-2035	IE1	IE2	IE3	IE4	Total	Total installation costs bln (mln USD)	Needed man-years installation
IE1 MEPS replacement mln USD	163	15	7	1	187	5	326
IE2 MEPS replacement mln USD	-	201	7	1	209	5	326
IE3 MEPS replacement mln USD	-	-	223	1	225	5	326
IE4 MEPS replacement mln USD	-	-	-	240	240	5	326

Appendix K.

Additional needed investment USD and workforce in man-year for EE-EMDS's

In Section 3.3 we have estimated the present (2014) electric motor stock in Indonesia in terms of number of motors with a certain capacity. These motors will have to be replaced the next coming 20 years. We assume that these motors all run a system, as pumping, compressed air and fan systems. Note that this assumption could be an exaggeration when electric motors are joined and working together within the same EMDS.

The only sources that says something about investments costs in EMDS's, besides the investment costs for the electric motors itself, is (McKane & Hasanbeige, 2010), as shown in the following table for pumping systems. These costs include US labour costs which are presented in a different table. As an example; 20% of the investment costs for 'Replace motor with more energy efficient type' is related to labour cost. The same way (McKane & Hasanbeige, 2010) presents investment costs for compressed air and fan systems.

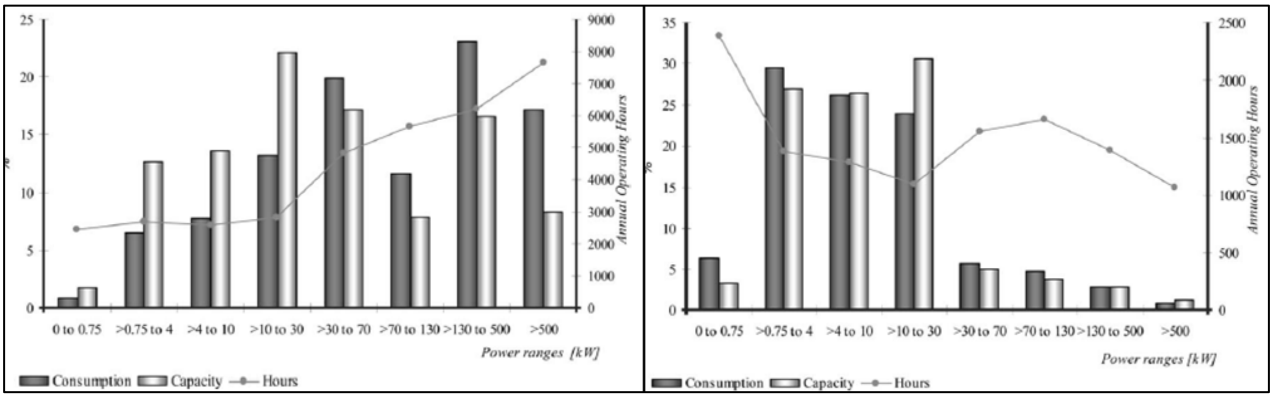
Figure 29: Investments costs for pumping systems (McKane & Hasanbeige, 2010)

No.	Energy Efficiency Measure	Typical Capital Cost (US$)				
		≤ 50 hp	>50 hp ≤ 100 hp	>100 hp ≤ 200 hp	>200 hp ≤ 500 hp	> 500 hp ≤ 1000 hp
		≤ 37 kW	> 37kW ≤ 75kW	> 75kW ≤ 150kW	> 150kW ≤ 375kW	> 375kW ≤ 745kW
1.1	**Upgrade System Maintenance**					
1.1.1	Fix Leaks, damaged seals, and packing	$1,000	$1,500	$2,000	$2,500	$3,000
1.1.3	Remove scale from components such as heat exchangers and strainers	$6,000	$6,000	$9,000	$12,000	$15,000
1.1.3	Remove sediment/scale buildup from piping	$3,500	$3,500	$7,000	$10,500	$14,000
1.2	**Eliminate Unnecessary Uses**					
1.2.1	Use pressure switches to shut down unnecessary pumps	$3,000	$3,000	$3,000	$3,000	*
1.2.2	Isolate flow paths to no-nessential or non-operating equipment	$0	$0	$0	$0	$0
1.3	**Matching Pump System Supply to Demand**					
1.3.1	Trim or change impeller to match output to requirements	$5,000	$10,000	$15,000	$20,000	$25,000
1.4	**Meet variable flow rate requirement w/o throttling or bypass****					
1.4.1	Install variable speed drive	$4,000	$9,000	$18,000	$30,000	$65,000
1.5	**Replace pump with more energy efficient type**	$15,000	$30,000	$40,000	$65,000	$115,500
1.6	**Replace motor with more energy efficient type**	$2,200	$4,500	$8,000	$21,000	$37,500
1.7	**Initiate predictive maintenance program**	$8000	$8,000	$10,000	$10,000	$12,000

From section 2.6 we know what percentage of electricity consumption of electric motors goes to the main three systems: pumping, compressed air and fan systems. As an example, it can be calculated that 19% of the electricity consumption of electric motors, goes to pumping systems (industry and commercial sector combined). We make the assumption that as well 19% of the known Indonesian motor stock is combined with pumping systems. We do the same for the other two systems.

Now we can calculate investments costs and needed workforce for the individual energy efficiency measures. Obviously we have the possibility to compare and verify the outcome for only the replacement of the electric motor with the previous appendices. We noticed that after the calculation the average price for one single motor across the total motor stock was far higher than expected from **Table 19**. There could be a very simple reason for this. The data used from (McKane & Hasanbeige, 2010) is related to the industrial sector only. Our focus lies with the commercial sector as well. From (Almeida et al, 2003) we can observe that the installed capacity of electric motors within the commercial sector is far less compared to the industrial sector, as shown by **Figure 30**. In fact, the average for the industry seems to be around 30 kW – 70 kW (left figure), whereas the average for the commercial sector lies around 4-10 kW (right figure). This would tell us that the average installed capacity of an electric motor within the commercial sector is about 8% to 14% of an electric motor within the industrial sector.

Figure 30: Motor electricity use, installed capacity and number of annual operating hours by size range in the industrial and commercial sector (Almeida et al, 2003). The left figure shows the industry, the right picture the commercial sector.



When we simulate having a motor stock with smaller capacities by lowering unit prices in (McKane & Hasanbeige, 2010) with 66%, we do reach the a situation whereby the average price of an electric motors equals what has been calculated before[23]. Now we feel confident to proceed and to calculate the total investment costs and workforce needed, to implement *additional* energy efficiency measures, *besides* only replacing the electric motor with a more efficient one. Remember that these numbers only relate to pumping, compressed air and fan systems, which together consume 72% of the electricity consumption of all EMDS's in the commercial and industrial sector.

23 Note that still the original unit prices (excluding labour cost) used in (McKane & Hasanbeige, 2010) are valid prices, and are of the same magnitude as prices used in this report (Appendix D). It's just a matter of having far more electric motors of a smaller capacity within the capacity ranges mentioned in **Figure 29** that leads to a lower average price for the whole motor stock.

Table 22 gives the total additional needed investment, labour cost and workforce for implementing the energy efficient measures of (McKane & Hasanbeige, 2010) in Indonesian EMDS's, excluding replacing electric motors. The one but last row repeats the total investment cost for a MEPS on IE4, taken from **Table 17** and **Table 19**. The labour costs mentioned in this row concerns only the working hours and does not take into account any additional costs for food, travel and hotels. The last row shows with a factor the increase in investment costs and needed man-years relative to the IE4 MEPS scenario only.

We can conclude that 8 times more investment is needed. Since these measures are much more time consuming to implement, the total labour costs and needed man-years increases with a factor 18.

Table 22: Additional investment and work-force needed when a MEPS programme is expended with a focus on EE-EMDS's; year 2014

Type of energy efficient electric motor driven system (EE-EMDS)	Total investment (bln IDR)	Total investment (mln USD)	Total installation costs (bln IDR); only labour	Total installation costs (mln USD); only labour	Needed man-years
Pumping	67,351	5,046	2,057	154	17,509
Compressed air	48,328	3,621	1,230	92	10,469
Fan	33,618	2,519	516	39	4,395
Total	149,297	11,185	3,804	285	32,373
Compare IE4 MEPS only	18,729	1,403	205	15	1,905
Increasing factor (IE4/EE-EMDS)	8	8	19	19	17

By extrapolating[24] we project these numbers on the year 2035. Obviously we don't take into account effects as inflation.

24 We know from **Figure 18** that the electricity consumption for electric motors in the commercial and industrial sector will grow from 46 mln BOE in 2014 towards 157 mln BOE in 2035. By multiplying the numbers of **Table 17** with a growth-factor 157/46=3.4, we extrapolate towards 2035.

Table 23: Additional investment and work-force needed when a MEPS programme is expended with a focus on EE-EMDS's; year 2035

Type of energy efficient electric motor driven system (EE-EMDS)	Total investment (bln IDR)	Total investment (mln USD)	Total installation costs (bln IDR); only labour	Total installation costs (mln USD); only labour	Needed man-years
Pumping	230,691	17,284	7,047	528	59,971
Compressed air	165,533	12,402	4,214	316	35,860
Fan	115,150	8,627	1,769	133	15,053
Total	511,374	38,313	13,029	976	110,884
Compare IE4 MEPS only	64,150	4,806	702	53	6,525
Increasing factor (IE4/EE-EMDS)	8	8	19	19	17

When dividing by 20 years, we get the yearly average numbers of **Table 7** in Section 3.11:

Type of energy efficient electric motor driven system (EE-EMDS)	Total investment (bln IDR)	Total investment (mln USD)	Total installation costs (bln IDR); only labour	Total installation costs (mln USD); only labour	Needed man-years
Pumping	11,535	864	352	26	2,999
Compressed air	8,277	620	211	16	1,793
Fan	5,757	431	88	7	753
Total	25,569	1,916	651	49	5,544
Compare IE4 MEPS only	3,207	240	35	3	326
Increasing factor (IE4/EE-EMDS)	8	8	19	19	17

Appendix L.

Indonesian associations by industrial subsector

ISIC Section C: Manufacturing		
ISIC division	**Description**	**Association**
10+11+12	Food, Beverage, and Tobacco	Food and Beverage http://www.gapmmi.or.id/
		The Wheat Flour Association http://www.aptindo.or.id/
		Sugar Industry Association
	Manufacture of Vegetable and animal oils and fats (ISIC class 1040)	Indonesian Natural Oil Association http://www.gimni.org/
13+14+15	Textile, leather, shoe, sandal	Textile Association
		Fiber makers association http://www.fiber-indonesia.com/
16+31	Wood, furniture, and forestry	
17+18	Pulp & paper, print industry	Pulp and Paper industry association http://apki.net/?page_id=1945
		Packaging Federation http://www.packindo.org/
20+21+22	Chemical, fertilizer & rubber industry	Fertilizer Association http://www.appi.or.id/
		Indonesian Pharmaceutical Association
		The Indonesian Olefin & Plastic Industry Association http://www.inaplas.org/
		Indonesian Synthetic Resin Association http://www.arsi.or.id/
		Indonesia Woven Polyolefin Manufactures Association http://giatpi.com/#/menu/Home.html
19+23	Cement and non-metallic	Indonesia Cement Association http://www.asi.or.id/home
24+25	Iron and Steel industry	Indonesian Mold & Dies Industry Association http://www.imdia.or.id/english/index.html
28+29+30+33	Machinery industry	Machinery Association
		Indonesian Motorcycle Association http://www.aisi.or.id/
		The Association of Indonesia Automotive Industries http://www.gaikindo.or.id/
		Heavy Equipment Manufacturer Association of Indonesia http://www.hinabi.org/
26+27+32	Other	Indonesian Electrical Manufacturers Association http://appi-electric.co.id/

Note that besides these ‘manufacturing’ companies (ISIC Section C), there are as well companies that fall under other Sections, which have not been discussed so far:

- Section A: Agriculture, forestry and fishing
- Section B: Mining and quarrying
- Section D: Electricity, gas, steam and air conditioning supply
- Section E: Water supply; sewerage, waste management and remediation activities
- Section F: Construction
- Section G-U: Commercial sector

Appendix M.

Electricity consumption by subsector for the Netherlands

Table 24: Statistical data for medium and large size enterprises; edited (CBS, 2012; Odysee-Mure, 2015)

	ISIC division	Medium and large size enterprises	Number of enterprises	Number of employees	Average employees each enterprise	Electricity consumption (GWh)
		Year:	2012	2012	2012	2012
1	10+11+12	Food, Beverage, and Tobacco	765	96,683	126	5,264
2	13+14+15	Textile, leather, shoe, sandal	130	9,746	75	190
3	16+31	Wood, furniture, and forestry	330	22,371	68	127
4	17+18	Pulp & paper, print industry	405	34,637	86	1,728
5	20+21+22	Chemical, fertilizer & rubber industry	610	91,506	150	10,962
6	23	Cement and non-metallic	170	21,790	128	1,011
7	24+25	Iron and Steel industry	1,050	80,652	77	3,916
8	28+29+30+33	Machinery industry	1,150	107,454	93	2,224
9	26+27+32	Other	520	159,375	306	2,003
		Total medium add large enterprises	**5,130**	**624,214**	**122**	**27,426**
		Total small scale enterprises 2010	**49,745**	**158,786**	**3**	**5,776**
		Total whole industrial sector	**54,875**	**783,000**	**14**	**33,202**
		Medium and large % of whole sector	**9.3%**	**80%**		**83%**

Table 25: Electricity intensity by enterprise and employee

	ISIC division	Medium and large size enterprises	Average electricity consumption each enterprise (MWh)	Electricity consumption each employee (kWh)
		Year:	2012	2012
1	10+11+12	Food, Beverage, and Tobacco	6,881	54,442
2	13+14+15	Textile, leather, shoe, sandal	1,465	19,540
3	16+31	Wood, furniture, and forestry	385	5,675
4	17+18	Pulp & paper, print industry	4,267	49,896
5	20+21+22	Chemical, fertilizer & rubber industry	17,971	119,798
6	23	Cement and non-metallic	5,949	46,415
7	24+25	Iron and Steel industry	3,730	48,559
8	28+29+30+33	Machinery industry	1,934	20,700
9	26+27+32	Other	3,852	12,568
		Total medium add large enterprises	**5,346**	**43,938**
		Total small scale enterprises 2010	**116**	**36,375**
		Total whole industrial sector	**605**	**42,404**

Appendix N.

Share of total motors electricity consumption by subsector

From (Almeida et al, 2003) we know what share of the electricity consumption each subsector goes to electric motors. Although the information derives from the situation in Europe, we can use it as a guidance and project some of the findings on Indonesia. In **Table 26** , the share of motor electricity consumption is given for 6 industrial sectors, that are present in Indonesia as well. Other large Indonesian sectors that are not calculated in (Almeida et al, 2003) are the industries of 'Textile and Leather', and 'Non-Ferrous Metals'. As well the commercial sector is given, here described as the services sector.

The columns that follow give an indication of the technical and economical savings potential for the combination of EEEMs (energy efficient electric motors) and VSDs (Variable Speed Drives). The economic potential is defined as a payback period of three years for investments made. The table is sorted for highest economic %-savings potential (the last column).

Table 26: Share of motor electricity consumption and savings potential in the EU (%)

		1	2	3	4	5	6
	Sector	**Share of motor electricity consumption**	**Technical and economic potential EEMs**	**Technical potential VSD**	**Technical potential EEMs+VSD**	**Economic potential VSD**	**Economic potential EEMs+VSD**
1	Non-metallic mineral	91%	7%	22%	28%	16%	22%
2	Iron and steel	66%	6%	23%	28%	16%	22%
3	Machinery and metal	52%	6%	12%	17%	8%	13%
4	Services sector	38%	5%	10%	14%	5%	9%
5	Food, beverage and tobacco	90%	3%	7%	10%	5%	7%
6	Paper, pulp and print	75%	3%	8%	11%	4%	7%
7	Chemical	72%	1%	4%	6%	1%	2%
8	Other industry	60%	2%	7%	9%	4%	6%
9	Total industry sector	69%	3%	10%	13%	6%	9%
10	Total industry plus services	57%	4%	10%	13%	6%	9%

From this table we can conclude that the largest *relative* savings are to be found in the industrial sector of 'non-metallic minerals', the 'iron and steel industry' followed by 'machinery and metal'. This table tells us as well that the commercial sector lies by %-savings potential in between the other 6 industrial sectors.

The *economic* potential of EEEMs equals the *technical* potential (column 2), meaning that it is 'cost effective to apply EEEMs in all power ranges, leading to payback times less than three years'. This adds to the conclusions of pay-back calculations in Section 3.6.

For VSDs there are some situations in which the introduction of variable speed controls is not attractive, especially in the lower power ranges. In the industrial sector, with a large number of operating hours, the fraction of application in which VSDs are cost-effective is larger than in the commercial sector, where the number of operating hours is significantly less. The higher cost of electricity in the commercial sector partially compensates the reduction in operating hours (as observed as well in Section 3.6).

While the savings potential available in industry is concentrated in large motors, the savings potential available in the commercial sector is concentrated in motors below 30 kW, due to their relative importance in the use of electricity (Almeida et al, 2003).

Note that:

- Due to subsidized electricity prices in Indonesia, the %-savings potential could be lower, although we have seen in Section 3.6 that even subsidized prices often lead to cost-effective replacements of old motors.
- The economic savings potential for EEEMs only adds 3.3% in the industrial sector and 4.8% in the commercial sector (column 2), with a weighted average of 3.7%. Although it is not known with which IE-class this has been calculated, the *magnitude* of this percentage coincides with what has been calculated in Section 2.4, **Table 4**. The VSD's add 5.8% to this (column 5).
- From **Figure 9** and **Figure 10** we know that there are more system-components to consider that will add to the savings potential.

Appendix O.

Share of motors driven systems by subsector

From (Almeida et al, 2003):

Table 27: Share of electricity consumption electric motors by application (%)

		1	2	3	4	5=1+2+3+4	6	7
	Sector	**pumps**	**fans**	**air com-pressors**	**cooling com-pressors**	**First focus**	**conveyors**	**other motors**
1	Non-metallic mineral	7%	21%	17%	0%	45%	6%	49%
2	Iron and steel	1%	18%	17%	0%	37%	0%	63%
3	Machinery and metal	9%	15%	14%	0%	38%	5%	57%
4	Services sector	16%	24%	26%	17%	83%	11%	7%
5	Food, beverage and tobacco	10%	12%	9%	30%	60%	0%	40%
6	Paper, pulp and print	57%	22%	13%	0%	92%	1%	7%
7	Chemical	26%	11%	28%	6%	71%	3%	27%
	Other industry	22%	16%	18%	7%	61%	2%	36%
	Total industry sector	22%	16%	18%	7%	61%	2%	36%
	Total industry plus services	20%	18%	20%	9%	67%	4%	29%

Column 5 of **Table 27** tells us the share of electric motors, that are combined with pumps, fans and compressed air systems. The top-3 consists out of the [paper and pulp industry], the [commercial sector] and the [Chemical industry]. A description of the usage of electric motors is given below.

1. Non-metallic mineral sector: Mills, extruders, rollers and large production machinery are responsible for about half of the total motor electricity consumption in this sector, especially in the higher power ranges. Since most of the factories operate continuously, the average number of operating hours is high.

2. Iron and steel: The steel sector includes two types of operation: steel making and forming. Motors related to steel forming in rolling mills, sanding, casting and finishing, account for the largest share of motor electricity consumption. In steel making, pumping for cooling and fans for dust extraction are important loads in terms of electricity savings potential. Fans, which are excellent candidates for VSDs, are the second largest energy users, and are mainly used for dust and waste gas extraction and for air blowing. According to one of the interviewees, especially within this Indonesian industrial sector, 'bad performing' motors are to be found everywhere: "*If you walk around in this sector, you will feel like walking through an industrial museum*".

3. Machinery and metal: Pumps, fans and compressors only represent 38% of the total motor electricity consumption. Machine tools, handling equipment, robotic systems, cranes and process machinery have the largest share of motor consumption (63%). All motors, especially motors below 0.75 kW have low load factors, resulting in a significant drop in efficiency.

4. Commercial sector: Pumps, fans and compressors are by far the most important loads in the commercial sector, accounting for 83% of the total motor electricity consumption. Most motors, especially small motors are oversized. Motors up to 30 kW represent about 86% of the motor electricity consumption, making them a specific target when evaluating the energy savings with EEEMs.

5. Food, beverage and tobacco: Pumps, fans and compressors represent 60% of the motor electricity consumption, of which about half are for cooling compressors. When assessing the savings potential, the application of VSDs was only considered for variable loads of centrifugal type. Other motors include mixers, conveyor belts, packaging machines and processing machines. Motors up to 4 kW are significantly oversized, being particularly good candidates to be replaced with smaller EEMs when they fail. They represent an attractive opportunity for electricity savings, because of the relatively larger efficiency difference between standard and EEMs for motors up to 4 kW.

6. Paper, pulp and print: Centrifugal loads (pumps, fans and compressors) use about 92% of the motor electricity consumption in this sector. Pumps are by far the most important type of motor load, accounting for 57% of the total motor electricity consumption. The average number of operating hours is high

7. Chemicals: Pumps, fans and compressors represent about 71% of the total motor electricity consumption in this sector. This high share of controllable loads is responsible for the large savings potential identified in this sector. Motors above 130 kW are responsible for 63% of the total motor electricity consumption. Note that this coincides with a remark of ABB; they sell as well the larger motors to the chemical industry. Mixers, stirrers, agitators and dispersers are common motors in chemical plants.

8. Textile, leather, shoe and sandal industry: see (GIZ, 2013) for insight in the apparel and footwear industry.

Appendix P.

Overview of key policy instruments and their attributes (EMSA, 2014a)

Attributes	MEPS	Labels	Voluntary Agreements	Energy Management	Energy Audit	Motor Policy	Financial Incentives	Awareness and Information
Aim	Remove worst performing components or systems from the market	Provide information on the energy performance of components & systems. Helps to identify best-performing products.	Improve the efficiency of major sectors or companies through non-regulatory mechanisms	Maximize energy savings throughout individual companies	Identify cost-effective energy savings within individual companies	Adopt the most efficient motors that are cost-effective	Either to raise awareness of opportunities amongst end-users, or create long term improvements in the market	Overcome barriers due to a lack of awareness, information or skills
Target Group	Motor and system suppliers	Purchasers of motors & systems	High energy consuming sectors or companies	Individual businesses	Individual businesses	Individual businesses	Purchasers or suppliers of motors and systems	Purchasers and end-users of motors and systems
Speed to Implement	3-5 years before implemented	Voluntary labels (1-2 years) quicker than mandatory labels but take time to achieve brand awareness	Once framework established can be quick to implement, although dependent on voluntary uptake	1-2 years to implement. Requires long-term commitment to maximize impact	Once framework established can be quick to implement	Likely to be quick to implement	Quick to implement, but may not have a long life	Simple awareness and information programs will be quicker to implement than longer-term training and educational programs
Potential to Transform the Market	high	high	medium	medium	medium	medium	medium	low
Market Impact	Needs review and upgrading every 3-5 years to maintain impact	Once the label becomes a valued sales tool, can pull the market. Needs periodic upgrading to continue to provide market incentive	Can help to improve corporate understanding of energy savings and change business culture	Can help to improve corporate understanding of energy savings and change business culture	If programs are sufficiently long-run, these can establish a body of skilled auditors able to sell services to the market	Can help to improve corporate understanding of energy savings and change business culture	Market transformation can occur if measure raises sales to sufficient levels for economies of scale in efficient components to be maintained	Unlikely to achieve transformation on their own but may be part of a larger market transformation program
Financial Implication	Establishment and testing costs for governments Compliance costs for industry	Low cost to implement but needs marketing to educate end-users	Tends to be relatively low cost for governments, depending on the degree of support and incentives provided	Depends on the degree of support and incentives provided	Depends on the degree of support and incentives provided	Aimed at maximizing cost-effective investments by companies	Varied cost depending on the measure, and duration	Varied cost depending on the scale of the program

Appendix Q.

Interaction between key policy instruments (EMSA, 2014a)

Policy Measures	Labels	Voluntary Agreements	Energy Management	Energy Audits	Motor Policy	Financial Incentives	Awareness and Information
MEPS	Highly complementary. Both based on common test methods	All further policy measures may be used to complement MEPS, depending on the individual national legal, political, economic, cultural and environmental situation.					
Labels		Labels can help to specify the procurement criteria for industrial equipment		Labels can help energy auditors to recommend high efficient motors	Label specifications can be used as the basis for selection criteria	Work well together. Specifications for high efficiency components provide the basis for targeting financial measures	Labels require information programs to make end-users understand the information provided by the label
Voluntary Agreements			Voluntary agreements are one mechanism to encourage increased energy management	Energy audits may comprise one action under a voluntary agreement	Motor policy should form a part of a voluntary agreement	Financial incentives can be used to encourage participation in voluntary agreements	Awareness raising, benchmarking and staff training complement voluntary agreements
Energy Management				Energy audits may form one component of a wider policy on energy management	Motor policy should form a part of an overall energy management policy	Financial incentives can be used to focus attention on energy management opportunities	Awareness raising, benchmarking and staff training complement energy management programs
Energy Audits					An energy audit can be the first step towards developing a motor policy	Financial incentives can be used to promote implementation of audit findings	Awareness raising, benchmarking and staff training complement energy audit programs
Motor Policy						Motor policy can take advantage of financial incentives for high efficiency motors	Promotional campaigns can be used to highlight the benefits of motor policy. Training can support implementation of motor policy
Financial incentives							Financial incentives can help to raise awareness of energy efficiency opportunities

Appendix R.

Feedback motor and drive workshop GIZ

	Issue	Recommended Measures
1	There is a lack of awareness in industry to the significant energy and CO_2 savings that can be made from improvement in motor technology.	Guidebook on savings for motors and drives. To spread the word and help with capacity building, develop a simple guide. It is recommended that this covers the following main topics: • motor lifetime costs • load efficiencies • higher efficiency models and standards • motor repair inefficiencies • motor maintenance • drive train losses • motor management policy (MMP) • variable speed drives
2	Very few ESCos active in Indonesia	Energy auditing is seen as a useful tool to identify energy savings. While there are very few ESCo companies operating in Indonesia, there are good opportunities. ESCo should be promoted and be encouraged to provide free energy audits as part of the package offered.
3	Little use of motor management	The MMP in the training in these workshops was very well received. Simple demonstrations of an MMP should be included or added to Energy Management training. It would be good to develop a pilot project on MMP at a sample factory as part of PAKLIM's forward programme with an industrial company in the Food & Beverage or Pulp & Paper industries.
4	Little encouragement for energy efficient motors and drives This is seen as a pre-curser to tax relief on higher efficiency motors and drives, see 7 below.	Introduce a national campaign in Indonesia to encourage greater use of higher efficiency motors supported by the motor manufacturers or trade associations. This could be in the form of a reward scheme. A simple logo can be used by the motor efficient company on letter heads etc. There is no financial reward, only an opportunity for companies to promote their willingness to save CO_2. There is a good example of this in Europe called 'The European Motor Challenge Programme' and is supported by trade associations, see www.motor-challenge.eu. Similar programmes exist in the US under the Energy Star programme and also in other countries including Australia.
5	No female representatives from industry at the workshops	In Indonesian industry, motors and drives are possibly seen as a male issue. More should be done to promote technical energy savings issues through female participation, by preparing a motors and drives case study where females are actively involved.
6	Need legislation on minimum standards for electric motors	This is the ideal way to make sure all future electric motors are of the highest standard, it does however need time to be developed and put in place, and therefore the Motor Challenge Programme which can be introduced quickly and at low cost, is seen as the first step.
7	Reduced taxes on higher efficiency motors and drives	Similar to the UK enhanced capital allowance scheme, any industrial buyer of electric motors or variable speed drives can claim back some tax if they buy from a higher efficiency product list, see www.etl.decc.gov.uk This may be strongly linked to item 4.
8	Improve higher quality repair standards of motors	Most industrial users of electric motors get them re-wound when they break down and during this process significant inefficiency can be introduced, it is important to re-wind motors to the highest standard in order to avoid this. It is inevitable that industrial users will continue to get motors rewound as it is the cheapest option, so a quality standard is important.
9	Little advice available on motor maintenance leading to inefficiencies	Improved motor maintenance. Preventative maintenance can provide good savings in motor systems. The opportunities for savings should be brought to the attention of industrial users through training and MMP, see items 1 & 3.

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