READINESS AND PREPARATORY SUPPORT

MARKET ASSESSMENT OF THE ELECTRIC MOTORS AND DISTRIBUTION TRANSFORMERS IN LEBANON - AN ASSESSMENT OF ENERGY DEMAND AND GHG EMISSIONS FOR THE IMPLEMENTATION OF MEPS AND LABELS

Lebanon, *"Development of Energy Efficiency Standards and Labelling program for electric motors, transformers, washing machines and TVs in Lebanon".*

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PREPARED BY:

Project Lead

HEAT

Consortium Members

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ABBREVIATIONS & ACRONYMS

BAU	Business As Usual
BUR	Biennial Update Report
CAGR	Compound Annual Growth Rate
CO_2eq	Carbon Dioxide Equivalent
COM	Council of Ministers
EDL	Electricité du Liban
EE	Energy Efficiency
EU	European Union
GEF	Grid Emission Factor
GHG	Greenhouse Gas
GWh	Gigawatt Hour
GWP	Global Warming Potential
IEC	International Electrotechnical Commission
IPCC	Intergovernmental Panel on Climate Change
IRI	Industrial Research Institute
ISO	International Organization for Standardization
kW	Kilowatt
kWh	Kilo-watt Hour
LCC	Lifecycle Cost
LCEC	Lebanese Center for Energy Conservation
Libnor	Lebanese Norms Institution
MEPS	Minimum Energy Performance Standards
MIT	Mitigation
MOE	Ministry of Environment
MOP	Meeting of the Parties
MP	Montreal Protocol
MRV	Monitoring, Review, and Verification
MTCO2eq	Metric Tonnes of Carbon Dioxide Equivalent
NAMA	Nationally Appropriate Mitigation Action
NC	National Communication
NCP	National Cooling Plan
NDC	National Determined Contribution
NEEAP	National Energy Efficiency Action Plan
NOU	National Ozone Unit

Disclaimer

The data collection work in this report has been carried out during April, May, and June 2022. The quality of the obtained data from the industry is subject to the responsiveness of the industry and the accuracy of the shared data. Also, the authors of the report are still having clarifications on some of the obtained information. Particularly, there is a high degree of confidence on some subsectors, but a lower degree of confidence on the data for other subsectors (e.g., electrical motors). The newly incoming information and the results of the clarifications will be considered in the output files for the subsequent deliverables and under the final report. There will be a particular focus on the subsectors where a high degree of confidence could not have been obtained at this point in time.

1 BACKGROUND

MEPS (Minimum Energy Performance Standards) and Labels are a regulatory tool to prevent poor energy performing appliances to enter a market and to encourage markets to transition to high performing appliances. This is a tool that has been proven in many jurisdictions and its implementation in Lebanon would support GHG emissions reductions, reduce the stress on the electricity system, and reduce the cost of energy services to consumers.

This project focuses on generating the necessary documentation and advice for the government of Lebanon to implement MEPS regulations on four product classes: Television, Washing Machines, Electric Motors, and Distribution Transformers.

This report looks at the background policy and market environments to generate the necessary guidance, policy documents, and design the processes to support implementation and enforcement such as monitoring, verification, enforcement (MVE), communications and marketing, capacity building, and more. Specifically, this report will look at the following:

- Stakeholders – identify the key stakeholders needed for the development and implementation of MEPS regulations in Lebanon. Identify key responsibilities and opportunities.
- Legal and policy environment – Identify and assess existing policies to understand the possible relationships of MEPS and other tools, or existing processes.
- Market dynamics – To determine the levels of MEPS and labels for each product class and assess the market impact of the regulation in terms of potential energy savings and emissions reductions.

1.1 Key stakeholders

An assessment of current stakeholder looks at the government agencies, regulators, market participants, and possible elements from social and academic sectors based on the experience in other countries depending on the policy setup. In principle the focus will be on key government agencies that design and implement the policy and the needed look at participants to prevent a significant negative impact.

Other interested stakeholders will be enforcement agencies such as the customs department, supporting technical experts such as testing labs that could be private entities, universities, NGOs, or government owned. An initial assessment is provided in Table 1, but it is expected to grow as the process advances.

Table 1: Overview of the identified stakeholders for the implementation of MEPS and labels in Lebanon

Stakeholder	Roles and responsibility
LIBNOR	Lebanon's national standardization body that issue, publish, and amend national standards and grant the Lebanese conformity mark. LIBNOR would also have purview over energy performance standards.
Industrial Research Institute (IRI)	National authority for the testing of industrial equipment and appliances.
Lebanese Customs Authority	The authority in charge of controlling the imports of RAC appliances. Providing data on imports and exports of RAC equipment and refrigerants.
Ministry of Economy and Trade	The ministry of economy and trade has a consumer protection department, which is usually responsible for enforcing regulations and standards related to consumers.

EDL	The public electricity utility is mainly in charge of the procurement of distribution transformers.
Manufacturers and assemblers	Local manufacturers and assemblers of electric motors, and transformers; they will be directly affected by MEPS enforcement.
Ministry of Environment (MOE) – National ozone unit (NOU)	The ministry is the host of Lebanon's UNFCCC climate focal point and overseeing the majority of climate change and environmental projects in Lebanon. The ministry is also the National Focal Point for the Montreal Protocol and activities carried out under it.
Ministry of Energy and Water	Ministry responsible for the national electricity utility (EDL) and overseeing Lebanon's energy sector.
Order of Engineers and Architects	The national organizations hosting engineers and architects in Lebanon. The regularly publish reports and studies on energy performance in appliances and buildings.
LCEC	A center within the Ministry of Energy and Water responsible for energy efficiency and renewable energy activities. Their role includes setting up national strategies, implementing RE&EE initiatives, and supporting LIBNOR on standards and MEPS.
Ministry of Energy and Water	Ministry responsible for the national electricity utility (EDL) and overseeing Lebanon's energy sector.
Sellers	Retailers and sellers of TVs, washing machines, electric motors, and transformers in both retail and wholesale.
End users	Households and other users that buy and use TVs, washing machines, electric motors, and transformers. MEPS will have a direct impact on their energy consumption and maybe the cost of equipment.
Servicing companies	Companies that provide after-sales service to TVs, washing machines, electric motors, and transformers.

The following sections explain the adopted approach for the in-scope sectors' assessment including TVs, WMs, electrical motors and distribution and power transformers.

1.2 Legal framework

Lebanon is signatory to several international treaties such as the Montreal Protocol and Paris Agreement and has implemented national actions to achieve national and international targets including policies and regulations looking to reduce GHG emissions and support sustainable economic and environmentally friendly development to the country. A summary of the key actions and objectives is presented below:

- **Climate Change -** Lebanon signed the Paris Agreement in April 2016 and ratified in March of 2019. Lebanon submitted its first Nationally Determined Contribution (NDC) in September 2015 (Ministry of Environment, 2015). In the latest NDC[1], Lebanon's GHG are estimated to increase from 27 $MtCO_2eq$ in 2019 to over 43 $MtCO_2eq$ by 2030 under a business-as-usual scenario. Without international support, Lebanon has committed to lowering its emissions to 36 $MtCO_2eq$. With international support Lebanon

[1] https://unfccc.int/sites/default/files/NDC/2022-06/Lebanon%27s%202020%20Nationally%20Determined%20Contribution%20Update.pdf

has committed to lower the emissions by 2030 to about 30 $MtCO_2eq$. The NDC document identifies actions to reduce emissions and to support the electricity sector infrastructure faces when confronted with increased demand from a growing population, refugees' movement, and increased used of electric appliances. It is of note that the estimated GHG scenarios for the NDC in 2019 have now been invalidated due the compound crisis (political, economic, banking, etc) that has led Lebanon into a recession, and the expected emissions reductions that come with that. Despite this, the NDC commitments remain valid until they are updated.

- **Energy policies -** Lebanon has publishes several national policies aiming to improve the performance of the sector and to reduce the GHG emissions. Some of the key ones include:
    - **National Energy Efficiency Action Plan (NEEAP) 2016-2020**. The NEEAP addresses both primary and end-user-oriented energy savings. The decarbonization of the energy supply has been addressed through the National Renewable Energy Action Plan 2016-2020[2].
    - **Electricity Reform Plan**: The Electricity Reform Strategy aims to reform Lebanon's electricity sector, which has long suffered from high costs, inefficiencies, and blackouts. The strategy includes measures to improve the efficiency of the electricity sector, increase the use of renewable energy sources, and attract private investment.
    - **National Energy Policy**: The National Energy Policy aims to ensure the country's energy security, promote the use of renewable energy sources, and reduce greenhouse gas emissions. The policy includes measures to increase energy efficiency, diversify the energy mix, and develop renewable energy sources, such as solar, wind, and biomass.
    - **Green Building Code**: Lebanon is developing a Green Building Code, which aims to promote sustainable building practices and reduce energy consumption in buildings. The code includes requirements for energy-efficient lighting and HVAC systems and appliances, insulation, and the use of renewable energy sources.
    - **The Ministry of Energy and Water National Policy Statement for 2022[3]**, entitled "Setting Lebanon's Electricity Sector on a Sustainable Growth Path", outlines actions and strategies to improve the electricity sector in Lebanon. It is published by the Ministry of Energy and Water in March 2022, and is based on the Least Cost Generation Plan prepared by Électricité de France EDF in September 2021, and on "Lebanon Power Sector Emergency Action Plan" developed by World Bank in 2020. The plan rests on 5 main pillars, that are increasing supply hours while preparing to increase generation capacity on the grid increasing generation by commissioning three new power plants with the participation of the private sector, improving performance of the network, reducing losses, and enhancing collection, achieving financial sustainability, and addressing the regulatory and legislative frameworks, among which is proposing amendment to law 462.
    - **The energy conservation law draft** was submitted to the council of minister and approved earlier this year, but still not ratified by the parliament. This law includes provisions to

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[2] https://lcec.org.lb/sites/default/files/2021-02/NEEAP%202016%202020.pdf

[3] https://energyandwater.gov.lb/mediafiles/articles/doc-100778-2022_03_31_10_22_46.pdf

enhance energy efficiency, especially auditing environmental standards, applied by the industrial sector, related to energy efficiency of industrial products, among others.

  - **Law 462/2002** [4] calls for the establishment of Electricity Regulatory Authority (ERA). However, political turmoil delayed the actual implementation and enforcement of the law. ERA has not yet been formed, as of 31 December 2022. The ministry of energy and water is working on preparing a draft law specifying the proposed amendments to this legislation.

- **Institutional development - Law reference 23-07-1962** for the establishment of a public entity called "The Lebanese Standards Institution", was enacted by the Lebanese Parliament and it covers the roles and tasks that LIBNOR has to undertake (Standardization, NL Conformity Mark, Training, Enquiries, etc.) and the composition of the Board of Directors and it nominates LIBNOR as the Representative of the Lebanese Republic in International and Regional standardization activities.

Within this context, while energy efficiency is envisioned to play a key role in the government's climate and development objective, it has yet to implement MEPS and Labels regulations for energy consuming appliances. This is a tried and proven tool that ensures that poor performing appliances are not dumped in the Lebanese market as well as encouraging the market to aim for top performing appliances. This project aims to lay the foundational work needed to implement MEPS and labels for four key energy using appliances television, washing machines, distribution transformers, and electric motors. Further, once an overarching MEPS and Labels regulation is implemented and demonstrated with the four product classes targeted, it is relatively easy to expand it into other consuming products such as fridges, air conditioners, and more.

1.3 Sectors' inventory survey

The market assessment requires relevant, up-to-date, data to support analysis to determine the dynamic flows, assess the impact of possible policies, enable the determination of the MEPS levels, and design the ancillary components of a MEPS policy. The first step of this process is to perform a data collection from the market with a focus on sales, operating stocks, and the technical specifications of the units in the market.

In Lebanon, there are few data sources to support this kind of analysis requiring the implementation of a hybrid approach that looked at both, bottom-up and top-down data options, to generate sufficient information and fill the gaps where possible.

1.3.1 Data collection process

The data for this inventory was collected from primary and secondary sources. This included field surveys collecting information directly from appliances sellers, interviews with market participants, and desk research looking at existing data sources such as customs data, previous research, national statistical sources, and academic papers.

1.3.1.1 Primary Data

For electric motors and transformers, supplier-specific surveys were conducted among distributors, major importers, and manufacturers, covering more than 85% of the overall electric motors market, and more than 90% of the distribution transformers market.

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http://www.databank.com.lb/docs/Law%20No%20462%20Regulation%20of%20the%20Electricity%20sector.pdf

The surveys were conducted through several visits and interviews with companies' representatives and included the major supplier of electric motors such as (Kettaneh Sarl, Raymond Feghaly SARL, Raymond Feghaly SARL, Ayanian, Mohamad Fares, and Hermes) and distribution and power transformers such as (Matelec, LES, and Feghali).

Additionally, for its major role in the procurement of distribution and power transformers, EDL was met and interviewed through meetings with the head of technical studies department, Mr. Raja Al Ali.

Figure 1: Samples of motors from sales points where data was collected.

The data were collected with the support of a mandate letter issued by the Ministry of Environment to aid with the project.

1.3.1.2 Secondary data

Secondary data included review of different open sources that rely mainly on customs data and other available reports and studies to include:

1. **Market statistics** from the Central Administration of Statics (CAS) including any existing information on appliance sales, ownership, and use.
2. **Customs data** on the imports of appliances into the country. The customs data for the relevant projects was found to have some difficulties such as measuring imported television in tons or USD value instead of number and type of units.
3. Other **macro statistics** from CAS or international sources such as the World Bank including population, household size, GDP growth, and energy supply.
4. **Existing research** and **reports** providing information on previously collected information and analysis carried to provide information on the Lebanese market and emerging patterns.
5. Internationally accepted modelling default values associated with appliance lifecycles and energy efficiency potential.
6. The United Nations U4E (United for Efficiency) programme model regulation provided methodologies to provide annual energy consumption for appliances at different energy efficiency values.

Current and historical data are based, where available, on factual data from the sources listed above. Future projections are based on statistical data for population and economic growth projections.

The following challenges were encountered during the data collection work from the primary data sources:

- Reluctance to provide information or willingness to provide only partial information due to the confidentiality policy of some companies.
- Lack of statistical information at suppliers' and dealers' level.

- The recent economic crisis the country is going through made finding representative data very difficult, especially with the drastic changes to purchase behaviour.

1.3.2 Modelling parameters

For the analysis of this inventory, the modelling parameters derived from primary and secondary data collection as shown in section 1.3.1**Fehler! Verweisquelle konnte nicht gefunden werden.** were applied. The modelling parameters are derived from questionnaires and information from interviews where possible. Gaps were filled with values from HEAT's expert judgement and similar assessments in other countries, with special consideration to the case of Lebanon.

According to recent World Bank data, the Lebanese economy suffered due to the recent uprising in 2019. According to **Fehler! Verweisquelle konnte nicht gefunden werden.** (a), the GDP grew at an average rate of 3.7% between 2012 and 2018. The Lebanese GDP between 2012 and 2018 can be estimated as a linear function with years as:

$$GDP = 1.725 \times year - 3{,}426.004$$

However, a recent prediction from the IMF as shown in Table 2 depicts that the Lebanese economy will continue to contract at the rate of 0.5% under the status quo scenario and may be able to expand at an average rate of 2.82% in the case of reformed policies scenarios. As such, the prediction carried assumed low, medium, and high CAGR based on -0.5%, 1.5%, and 3% economic growths based on national statistics generated by the Lebanese Government (Table 2 and Table 3).

Table 2 Key selected indicators 2021-2027, Status Quo Scenario (Source: Lebanese authorities & IMF Staff estimates and projections.

Key selected indicators under the **Status Quo** Scenario (2021-27)	Act/Estimate		Projections				
	2021	2022	2023	2024	2025	2026	2027
Growth (%)	-10.0	0.0	-0.5	-0.5	-0.5	-0.5	-0.5
Consumer Prices (%, average)	154.8	171.2	296.1	152.6	135.1	169.0	207.3
Nominal GDP (Billions of USD)	20.5	21.8	13.7	13.2	12.8	12.5	12.3
REER (cumulative since 2019)	-31.8	-26.5	-53.7	-55.1	-56.1	-56.9	-57.6
Current account (% of GDP)	-17.3	-29.0	-20.0	-19.1	-9.6	-7.2	0.2
Overall fiscal balance (% of GDP)	1.2	-5.2	-9.2	-8.7	-6.7	-6.7	-6.3
Primary fiscal balance (% of GDP)	2.4	-4.3	-5.5	-5.4	-4.9	-5.4	-5.6
Public gross debt (% of GDP)	349.9	282.3	512.0	453.2	485.3	516.7	547.5

Table 3 Key selected indicators 2021-2027, Reform Scenario (Source: Lebanese authorities & IMF Staff estimates and projections.

Key selected indicators under the **Reform** Scenario (2021-27)	Act/Estimate		Projections				
	2021	2022	2023	2024	2025	2026	2027
Growth (%)	-10.0	0.0	-0.5	3.9	4.5	3.2	3.0
Consumer Prices (%, average)	154.8	171.2	296.1	148.7	75.1	33.6	12.1
Nominal GDP (Billions of USD)	20.5	21.8	16.2	18.2	24.7	26.7	27.9
REER (cumulative since 2019)	-31.8	-26.5	-46.1	-41.9	-24.5	-20.7	-20.2
Current account (% of GDP)	-17.3	-29.0	-12.5	-12.2	-11.0	-9.3	-6.0
Overall fiscal balance (% of GDP)	1.2	-5.2	-6.9	-19.9	-3.5	-2.0	-1.7
Primary fiscal balance (% of GDP)	2.4	-4.3	-3.5	-16.3	-0.6	0.7	0.9
Public gross debt (% of GDP)	349.9	282.3	509.3	110.0	91.5	83.6	80.9

Finally, it was important to find or estimate the ratio between the market growth/expansion and typical replacement used in the different sectors. The macro-economic data based on the proposed model was used assuming that all imports/GDP in 2020 (most significant GDP disruption) were used to focus on replacement. In this case, the replacement ratio was calculated as the ratio of the 2020 actual GDP/2020 BAU GDP as shown below:

$$Replacement\ Ratio = \ Percent_{Replacement,2020} \times \frac{2020\ Actual\ GDP}{2020\ BAU\ GDP}$$
$$= 100\% \times \frac{26.2}{1.725 \times 2020 - 3426.004} = 44.79\%$$

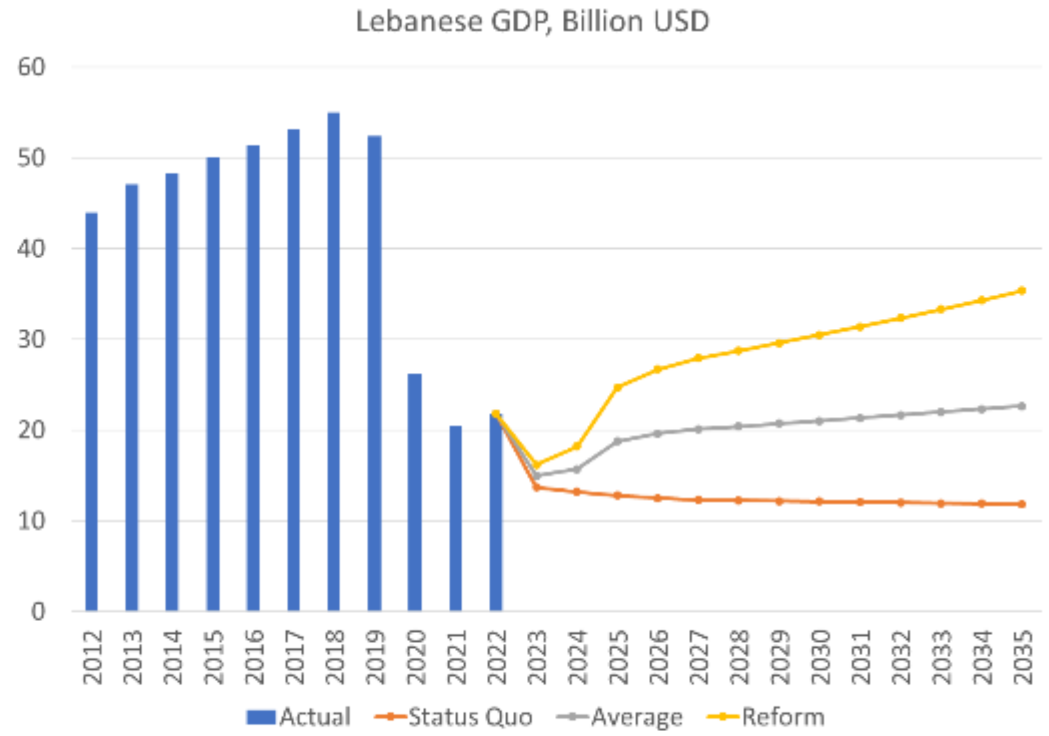

Figure 2: Proposed GDP forecast model with Low, BAU, and High economic growth scenarios.

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The population growth in Lebanon is summarized in Table 4. It shows that the estimated there would be slight decline in population in the decade 2020-29 followed by steady population thereafter. Further, the size of households continues to decrease meaning an increased total number of households for the available population. As many appliances' ownership is based on the household unit rather than the individuals, this is also placing increased demand on appliances.

Table 4: Population and household growth assumptions[5]

[5] Data taken from https://data.worldbank.org/indicator/SP.POP.TOTL?locations=IN

	Compound Annual Growth Rates (CAGR)				
	2018	2010-19	2020-29	2030-39	2040-49
Population	6,848,925	3%	-1%	0%	0%
Households	1,349,470	3%	-1%	1%	0%

Lebanon already has a very high urbanisation rate which currently stands at 88.6% (see Table 5). The Urbanisation will remain at a very high level until 2050 and slightly increase towards 93.4%.

Table 5: Current and projected urbanization[6] growth

	Compound Annual Growth Rates (CAGR)				
	2018	2020	2030	2040	2050
Urbanisation	88.6%	88.9%	90.6%	92.1%	93.4%

As mentioned in the modelling parameters section, the Lebanese economic growth will be a major driver for a still increasing demand for appliances. The economic growth assumptions for the three assumed growth scenarios status quo, intermediate, and intervention are: -0.5 %, 1.5% and 3.0% respectively.

Specific modeling parameters were developed based on local market survey, U4E Country Savings Assessments Methodology and Assumptions, and other best practices for the different import categories of electric motors (EMs) and distribution transformers (DTs) as shown in Table 6.

[6] See https://population.un.org/wup/Country-Profiles/

Table 6: Modelling parameters for the BAU scenario

Equipment type	Capacity (est.)	Lifetime [years]	Stock in 2022 (est.)	Market Size in 2022	BAU energy demand per unit kWh/yr	Min. ambition unit energy demand kWh/yr	Max. ambition unit energy demand kWh/yr
AC motors, single-phase, of an output > 37.5 W	120 W	11	2,590,200	172,500	94	80	71
AC motors, multi-phase, of an output > 37.5 W but <= 750 W	370 W	6	559,800	70,700	837	771	721
AC motors, multi-phase, of an output > 750 W but <= 75 kW	20.25 kW	6	89,100	8,800	49,337	48,610	47,884
AC motors, multi-phase, of an output > 75 kW	267 kW	7	1,500	160	1,324,636	1,312,209	1 300,657
Transformers, having a power handling capacity > 1 kVA but <= 16 kVA (excluding liquid dielectric)	5 kVA	20	15,200	900	3,530	2,584	1,866
Liquid dielectric transformers, having a power handling capacity <= 650 kVA	250 kVA	20	16,100	300	12,812	9,746	7,512
Liquid dielectric transformers, having a power handling capacity > 650 kVA but <= 10,000 kVA	1000 kVA	20	3,900	80	31,082	26,866	20,634
Transformers having a power handling capacity > 16 kVA but <= 500 kVA (excluding liquid dielectric)	250 kVA	20	8,000	220	16,928	12,877	11,546
Transformers having a power handling capacity > 500 kVA (excluding liquid dielectric transformers)	1000 kVA	20	950	18	35,661	30,824	29,466

2 ELECTRICAL MOTORS MARKET ASSESSMENT

The import/export data for electrical motors were used along with the survey data in order to establish the inventory of electrical motors in Lebanon. Table 7 below includes a summary of Lebanon's electric motors imports from 2017 to 2021. Survey results and literature review suggested that the most representative size for each of these AC motor categories are:

- AC motors, single-phase, of an output > 37.5 W: 0.12 kW
- AC motors, multi-phase, of an output > 37.5 W but <= 750 W: 0.37 kW
- AC motors, multi-phase, of an output > 750 W but <= 75 kW: are composed
    - 60% 2.2 kW,
    - 20% 15 kW, and
    - 20% 75kW
- AC motors, multi-phase, of an output > 75 kW: 500 kW

Table 7: Electric motor imports, thousands USD

Code	Product label	2017	2018	2019	2020	2021
850140	AC motors, single-phase, of an output < 37.5 W	4,350	3,466	2,981	1,145	1,836
850151	AC motors, multi-phase, of an output > 37.5 W but <= 750 W	1,538	1,289	1,345	853	1,196
850152	AC motors, multi-phase, of an output > 750 W but <= 75 kW	8,496	7,648	4,478	2,143	2,400
850153	AC motors, multi-phase, of an output > 75 kW	901	572	930	546	714

During the survey, suppliers provided the suggested retail prices for different types of electrical motors with different origin and efficiency levels. For the baseline IE1 electrical motors, the retail price may be expressed as shown in the following equation:

$$retail\ price = \begin{cases} 43{,}63P_{rated} + 112, & P_{rated} \leq 0{,}75\ kW \\ -124{,}71P_{rated} + 124{,}67, & P_{rated} > 0{,}75\ kW \end{cases}$$

In order to establish the market size in units, the values of imports from Table 7 are divided by the cost. Unfortunately, the cost to price ratio can't be assumed to be constant due to the difference in premium and supply chain challenges for the different motor categories. Another cost correlation was developed based on calibration with the sparse data available in the number of units in the ComTrade database. The final EM imports were calculated as shown in Table 8.

Table 8: Electric motor imports, thousand units.

Code	Product label	2017	2018	2019	2020	2021
850140	AC motors, single-phase, of an output < 37.5 W	381	304	261	100	161
850151	AC motors, multi-phase, of an output > 37.5 W but <= 750 W	90	76	79	50	70
850152	AC motors, multi-phase, of an output > 750 W but <= 75 kW	25	22	13	6	7
850153	AC motors, multi-phase, of an output > 75 kW	0.2	0.1	0.2	0.1	0.2

2.1 Distribution and power transformers market assessment

The import/export data for distribution and power transformers were used along with the survey data in order to establish their inventory in Lebanon. Table 9 below includes a summary of relevant Lebanon's distribution and power transformer imports from 2017 to 2021. Survey results and literature review suggested that the most representative size for each of category is:

- Transformers, having a power handling capacity > 1 kVA but <= 16 kVA (excluding liquid dielectric transformers): 5 kVA.
- Liquid dielectric transformers, having a power handling capacity <= 650 kVA: 250 kVA.
- Liquid dielectric transformers, having a power handling capacity > 650 kVA but <= 10,000 kVA: 1,000 kVA.
- Transformers having a power handling capacity > 16 kVA but <= 500 kVA (excluding liquid dielectric transformers): 250 kVA.
- Transformers having a power handling capacity > 500 kVA (excluding liquid dielectric transformers): 1,000 kVA.

Table 9: Relevant distribution and power transformer imports, thousands USD.

Code	Product label	2017	2018	2019	2020	2021
850432	Transformers, having a power handling capacity > 1 kVA but <= 16 kVA	1,625	634	724	313	4,065
850421	Liquid dielectric transformers, having a power handling capacity <= 650 kVA	6,118	1,206	4,233	284	1,461
850422	Liquid dielectric transformers, having a power handling capacity > 650 kVA but <= 10,000 kVA	2,592	452	1,136	167	1,070
850433	Transformers having a power handling capacity > 16 kVA but <= 500 kVA (excluding liquid dielectric transformers)	249	116	213	213	264
850434	Transformers having a power handling capacity > 500 kVA (excluding liquid dielectric transformers)	389	264	670	36	0

During the survey, suppliers provided the suggested retail prices as a function of the rated transformer capacity as follows:

- 50 kVA: USD $2,500 - USD $3,000
- 250 kVA: USD $5,000 - USD $6,000
- 1000 kVA: USD $15,000 - USD $17,000

In order to establish the market size in units, the values of imports from Table 9 are divided by the cost. The cost was assumed to be 50% of the retail price for small DTs (≤16 kVA), 25% for medium sized DTs (≤650 kVA) and 12.5% for large DTs (> 650 kVA) to account for the supply chain and profit margins. This resulted in a in the number of units in Table 10.

Table 10: distribution and power Transformers imports, units

Code	Product label	2017	2018	2019	2020	2021
850432	Transformers, having a power handling capacity > 1 kVA but <= 16 kVA	1,625	634	724	313	4,065

850421	Liquid dielectric transformers, having a power handling capacity <= 650 kVA	5,562	1,096	3,848	258	1,328
850422	Liquid dielectric transformers, having a power handling capacity > 650 kVA but <= 10,000 kVA	1,134	198	497	73	468
850433	Transformers having a power handling capacity > 16 kVA but <= 500 kVA (excluding liquid dielectric transformers)	226	105	194	194	240
850434	Transformers having a power handling capacity > 500 kVA (excluding liquid dielectric transformers)	170	116	293	16	0
	Total Number of Units	**8,717**	**2,149**	**5,556**	**854**	**6,101**

2.2 Development of the in-scope equipment's sales and stock figures

2.2.1 Equipment sales and stock for Electric Motors

Based on the modeling parameters described in sections above, the electric motors sector market and stock were projected until the year 2050 as shown in Figure 3. The stock is set to grow from ~ 3 million electric motors in 2020 to 6.3 million electric motors in 2050. The impact of the economic crisis is captured by a dip in the market sales in 2018 – 2023 followed by increased growth from 2024 to 2025 followed by steady market growth thereafter. The market sales in 2050 are expected to be 750 thousand units.

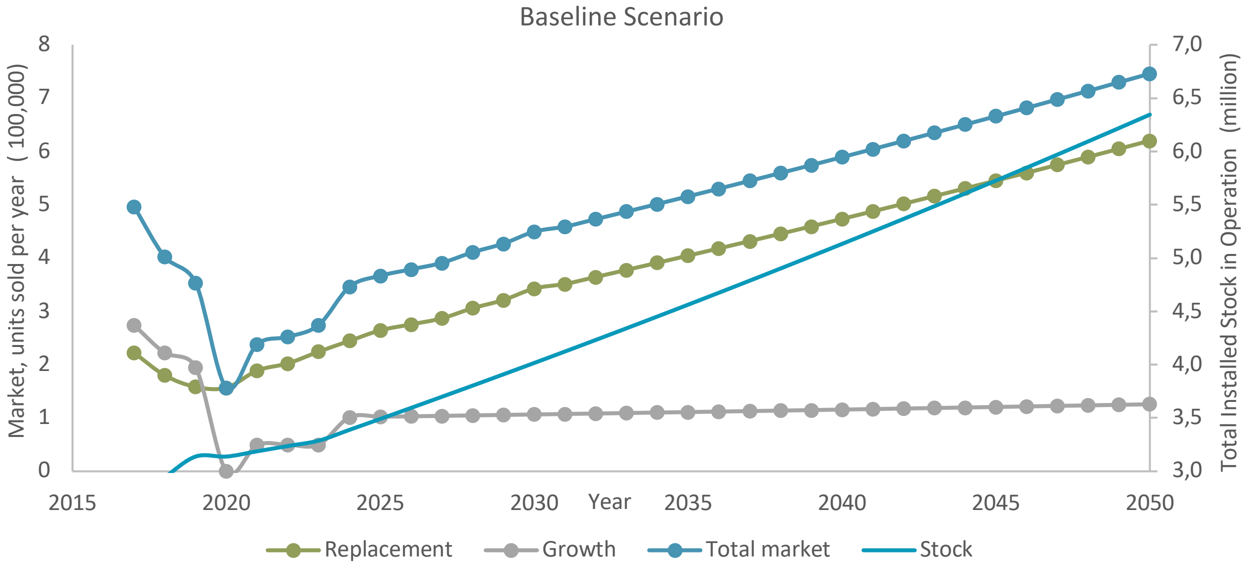


Figure 3. Electric Motors sales and stock under the baseline economic growth scenario.

The same estimates were made for the low-economic growth and high economic growth scenarios as shown in Figure 4 and Figure 5, respectively. These figures show that the market sales in 2050 may vary between 683 to 802 thousand units with a total stock ranging between 5.9 and 6.8 million units in 2050.

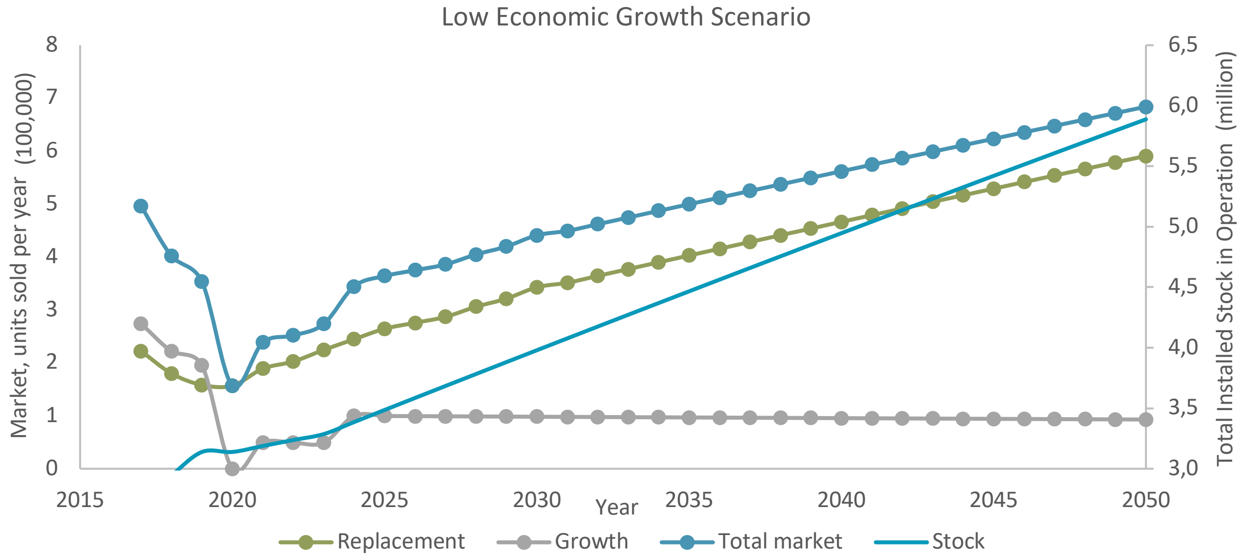


Figure 4. Electric Motors sales and stock under the low economic growth scenario.

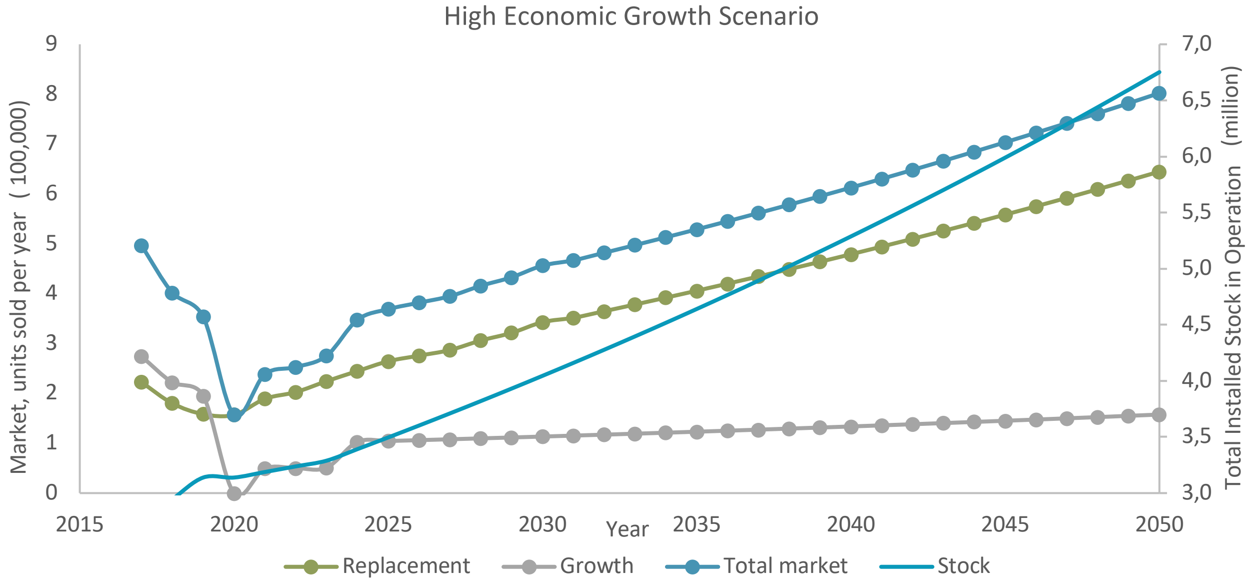


Figure 5. Electric Motors sales and stock under the high economic growth scenario.

2.2.2 Equipment sales and stock for Power and Distribution Transformers

Based on the modeling parameters described in sections above, the distribution transformer sector market and stock were projected until the year 2050 as shown in Figure 6. The stock is set to grow from ~ 39,000 units in 2020 to 142,000 units in 2050. The economic crisis in Lebanon has causes significant market disturbance as shown in the period 2017-2021. Distribution and Power Transformers are more strategic, and sales have gone through a surge in 2021 to recover after the economic crisis. This surge is less likely to continues and the market is expected to go back to normal by the year 2025. Afterwards, the market grows steadily until 2050. Figure 6 also shows that in the year 2021, there is a rise in the needed replacement transformers to account for the increase of units added to the market in the year 2021.

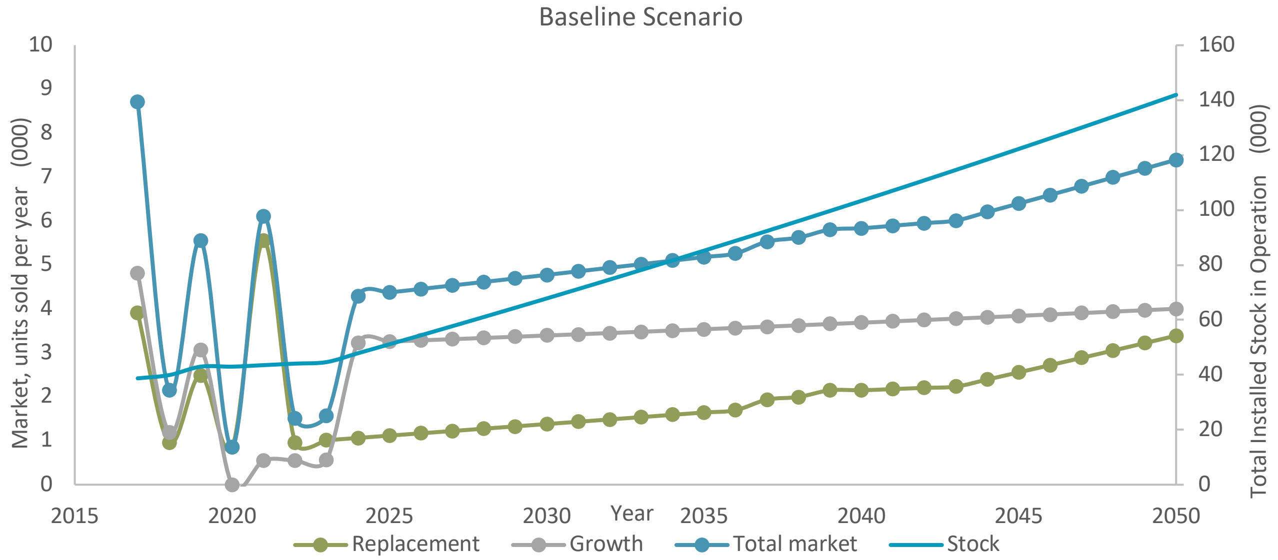


Figure 6. Distribution Transformers sales and stock under the baseline economic growth scenario.

The same estimates were made for the low-economic growth and high economic growth scenarios as shown in Figure 7 and Figure 8, respectively. These figures show that the market sales in 2050 may vary between 6,200 to 8,400 units with a total stock ranging between 126,000 and 154,000 units in 2050.

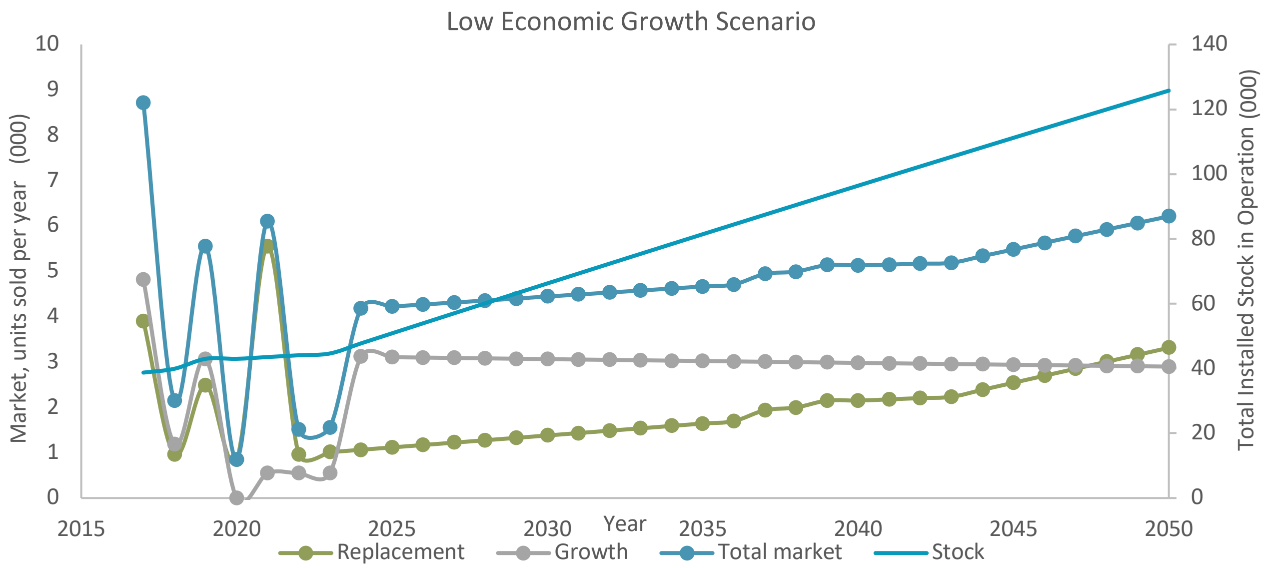


Figure 7. Distribution Transformers sales and stock under the low economic growth scenario.

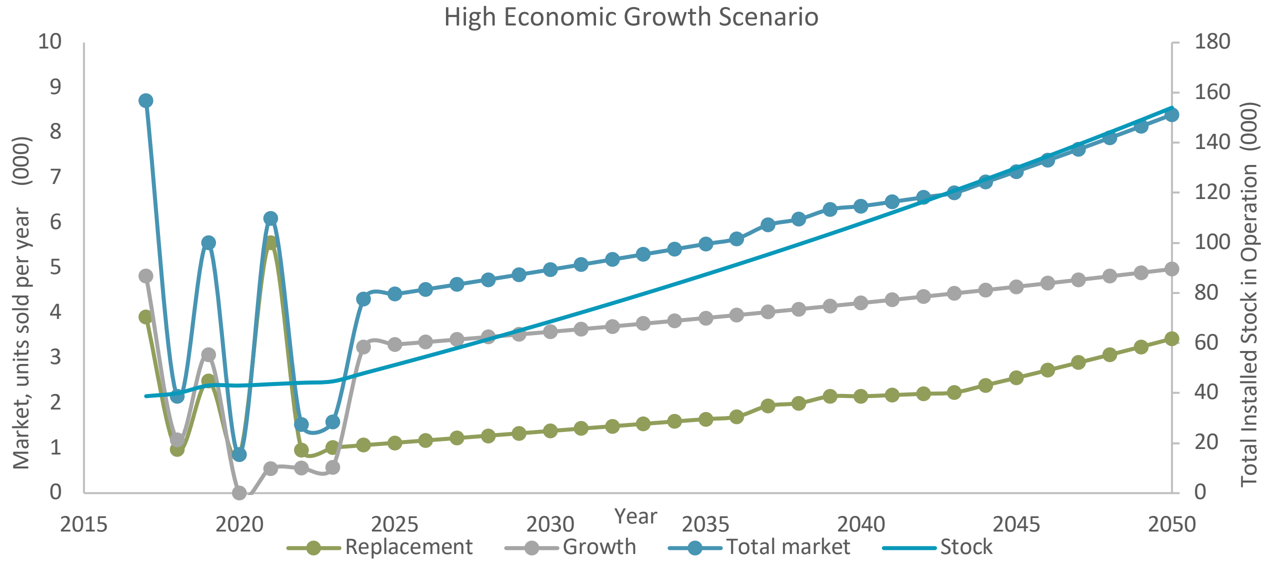


Figure 8. Distribution Transformers sales and stock under the high economic growth scenario.

2.2.3 Business as usual emissions

Recent estimates suggest that Lebanon CO_2eq emissions from the electric sector is at 0.663 kg per kWh for grid with private generators and 0.639 kg per kWh or grids without private generators. This study adopted an arithmetic average of 0.651 kgCO_2eq per kWh.

The estimated emissions from the electrical motors sector in 2021 are estimated to be 4.5 million metric tons of CO_2eq (MMTCO_2eq) emissions per year. Under the BAU scenario, this would grow to 15.1 MMTCO_2eq in 2050. Higher efficiency electric motors can provide up to 3.7% emissions reduction.

The estimated emissions from the distribution and power transformers sector in 2021 are estimated to be 0.36 MMTCO_2eq missions per year. Under the BAU scenario, this would grow to 1.25 MMTCO_2eq in 2050. Higher efficiency distribution and power transformers can significantly reduce the emissions associated with this vital sector by as much as 36.6%.

2.2.4 Emissions mitigation potential

It is important to consider international best practices when considering performance rating criteria. In the electrical motor sector, IEC 60034-1 is considered as the international best practice rating providing multiple efficiency levels namely “IE1”, “IE2”, and “IE3” with progressive efficiency increase. In this project, the guidance is to consider the transition towards “IE2” efficiency levels as the minimum ambition scenario. This would result in stock average unit energy savings of 14,000 to 24,000 kWh per year based on the motor category corresponding to emissions reduction ranging from 15 kgCO_2eq per unit to 15,600 kgCO_2eq per unit per year as shown in Table 11 below. The maximum ambition scenario which corresponds to a transition towards the IE3 efficiency level. This would result in significant energy savings improvement over IE1 – the current BAU as shown in Table 11.

Table 11: Electric motors energy and emissions savings per unit for the different categories for minimum and maximum ambition scenarios (L1 and L2, respectively).

AC Motors' Import Category	Market Avg. Capacity	L1 Energy Saving, kWh/unit/yr	L2 Energy Savings, kWh/unit/yr	L1 Emissions Reduction, $kgCO_{2eq}$/unit/yr	L2 Emissions Reduction, $kgCO_{2eq}$/unit/yr
Single-phase, of an output > 37.5 W	0.12	14	23	9	15
Multi-phase, of an output > 37.5 W but <= 750 W	0.37	66	116	43	76
Multi-phase, of an output > 750 W but <= 75 kW	20.25	727	1,453	473	946
Multi-phase, of an output > 75 kW	266.67	12,427	23,979	8,090	15,610

For the DT sector, the IEC 60076-20 is considered as the international best practice in DT energy efficiency rating. This standard provides multiple efficiency levels namely "Level 1", and "Level 2" with progressive efficiency increase. In this project, the guidance considers the transition towards "Level 1" efficiency levels as the minimum ambition scenario and towards "Level 2" efficiency levels as the maximum ambition scenario. The DT sector has significant potential as is shown in Table 12. This sector has an average energy savings potential per unit between 0.9 to 4.8 MWh annually in the minimum ambition scenario and between 1.7 to 6.2 MWh per year in the maximum ambition scenario. This corresponds to unit emissions reduction potential ranging from 0.6 to 3.1 tCO_2eq per year in the minimum ambition scenario and 1.1 to 4.9 tCO_2eq per year in the maximum ambition scenario.

Table 12: DT energy and emissions savings per unit for the different categories for minimum and maximum ambition scenarios (Level 1 and Level 2, respectively).

Import Category	Market Avg. Capacity	L1 Energy Saving, kWh/unit/yr	L2 Energy Savings, kWh/unit/yr	L1 Emissions Reduction, $kgCO_{2eq}$/unit/yr	L2 Emissions Reduction, $kgCO_{2eq}$/unit/yr
Transformers, having a power handling capacity > 1 kVA but <= 16 kVA	5	946	1,664	616	1,084
Liquid dielectric transformers, having a power handling capacity <= 650 kVA	250	3,066	5,300	1,996	3,450
Liquid dielectric transformers, having a power handling capacity > 650 kVA but <= 10,000 kVA	1,000	4,216	10,447	2,744	6,801
Transformers having a power handling capacity > 16 kVA but <= 500 kVA (excluding liquid dielectric transformers)	250	4,051	5,383	2,637	3,504
Transformers having a power handling capacity > 500 kVA (excluding liquid dielectric transformers)	1,000	4,837	6,195	3,149	4,033

3 LEBANON'S ELECTRICITY SYSTEM AND THE PROPOSED MEPS

The Lebanese electricity sector has been facing many challenges since the 1970s, with year 2018 recording a deficit of more than 30% in EDL's (Electricité du Liban) power supply network. EDL is the national power utility monopolizing the electricity sector. It is an autonomous state-owned company under the control of the Ministry of Energy and Water (MEW), that officially controls over 90% of the Lebanese electricity sector, leaving 10% to hydroelectric power plants owned by other public companies and concessions.

In 2018, EDL's installed capacity was 2,449 MW, meeting 66% of the country's increasing demand that was reported to be 3,669 MW that year. As demand for power increases, the gap between demand and EDL's limited supply capacity further widens.

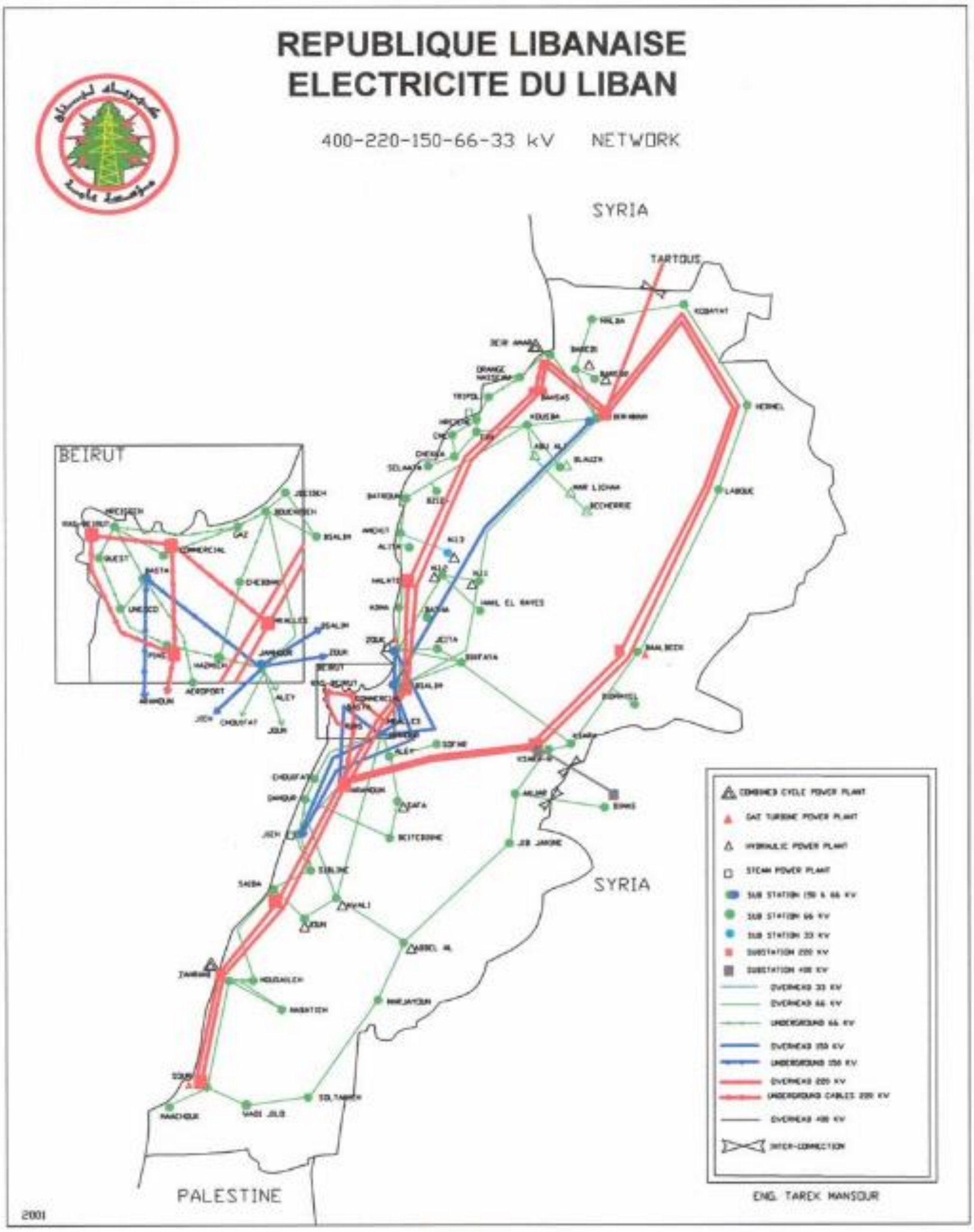


Figure 9. The high voltage electricity network in Lebanon[7]

The electrical grid in Lebanon is distributed to consumer at 230 V, 50Hz alternating current. The EDL transmission network is part of regional network first established in 1988, that includes the older 66-kV grid and some 150-kV transmission lines in certain areas. The newer 220-kV transmission line spreads over the

[7] http://www.geni.org/globalenergy/library/national_energy_grid/lebanon/lebanesenationalelectricitygrid.shtml

coastal areas and expands to the inner areas of Bekaa. The network currently suffers from transmission losses of 5.7%[8]. EDL is responsible for the transmission network and its transmission directorate is mandated to operate and maintain the transmission grid including substations.

In 2017, a transmission Master Plan was developed and approved to update the existing network, add new transmission lines, eliminate the 150 kV lines, expand the 220 kV lines, and cater for the expected injection of renewable energy power plants, yet this plan is still on hold to date.

The country relies heavily on fossil fuels, with more than 95% of electricity coming from heavy fuel oil and diesel production plants. In recent years, EDL has relied on imports from Syria and offshore privately-owned electricity barges to meet the demand it is unable to meet due to its limited aging plant. The observed capacities of the Syrian imports and electricity barges are 69 MW and 390 MW respectively. Yet, it remained incapable of providing 24/7 electricity, making room for privately-owned distributed generators to bridge the gap.

Indirect emissions are generated by the electrical generation plants, where electricity is produced to be used for the in-scope sectors, considering the annual electricity consumption and Lebanon's grid emission factor (GEF).

The grid emission factor (GEF) is a measure of the CO_2 emission intensity per unit of generated electricity in the total grid system. In the present study the GEF of 0.695 $kgCO_2eq$[9] has been used (it’s a combined grid/generators emission factor). As there are no future predictions of a potential GEF which can be implemented in the model, the data presented in this report uses the same GEF for the BAU and the MIT scenario.

3.1 The rationale for EE regulations for the in-scope sectors

As a member party to the Paris Agreement, Lebanon has committed itself to attain climate targets, i.e., net GHG neutrality latest by 2050. This goal can be supported through the implementation and strengthening of sectoral goals such as the reduction of energy demand from appliance usage. The 2030 (National Determined Contribution) NDC’s unconditional target for Energy Efficiency (EE) is currently a 3% reduction in electricity demand through the implementation of energy efficiency measures such as MEPS compared to the Business as Usual (BAU) scenario (this target increases to 10% with international support)).

Further, an effective implementation of MEPS can help to unlock economies of scale for products that save energy, reduce end-users’ energy costs, reduce air pollution, and cut GHG emissions from power generation.

With this in mind and added to the stated difficulties faced by the electricity system in Lebanon, the implementation of MEPS becomes an increasingly important tool, and is less of an optional policy and more of a necessity to support improvement in different sectors.

[8] https://energyandwater.gov.lb/mediafiles/articles/doc-100778-2022_03_31_10_22_46.pdf

[9] https://pub.iges.or.jp/pub/list-grid-emission-factor here applied as average operating margin emission factor.

3.2 The process for setting up safety and performance standards in Lebanon for energy consuming and energy related equipment

Figure 10 illustrates the process for setting up MEPS and labelling regulations in Lebanon. Currently, Lebanon has so far neither voluntary nor mandatory labels. To realize the climate and energy saving benefits as illustrated in Section 1.6 and Section 2, it is recommended to introduce mandatory MEPS and label standards. Most countries worldwide are moving to implement and enforce mandatory MEPS and labelling.

Preconditions for the realization of MEPS are the adoption of the most current international standards. The relevant international standards for electric motors are the IEC 60034 series and the international standards relevant for distribution power transformers are IEC 60076 series.

After defining the most relevant references, the second step is the formation of a technical committee for the development of the related standards. Libnor has already a Technical Committee which includes different members from public and private sectors.

The committee, through its continuous meetings, can develop safety standards and performance standards for the needed equipment in a consensus-based approach.

When the standards are approved by the committee members, a two months' trial period is set before publishing the standard in the national gazette.

Following the approval of LIBNOR's board of directors, these standards can become mandatory through decrees issued by the Council of Ministers (COM).

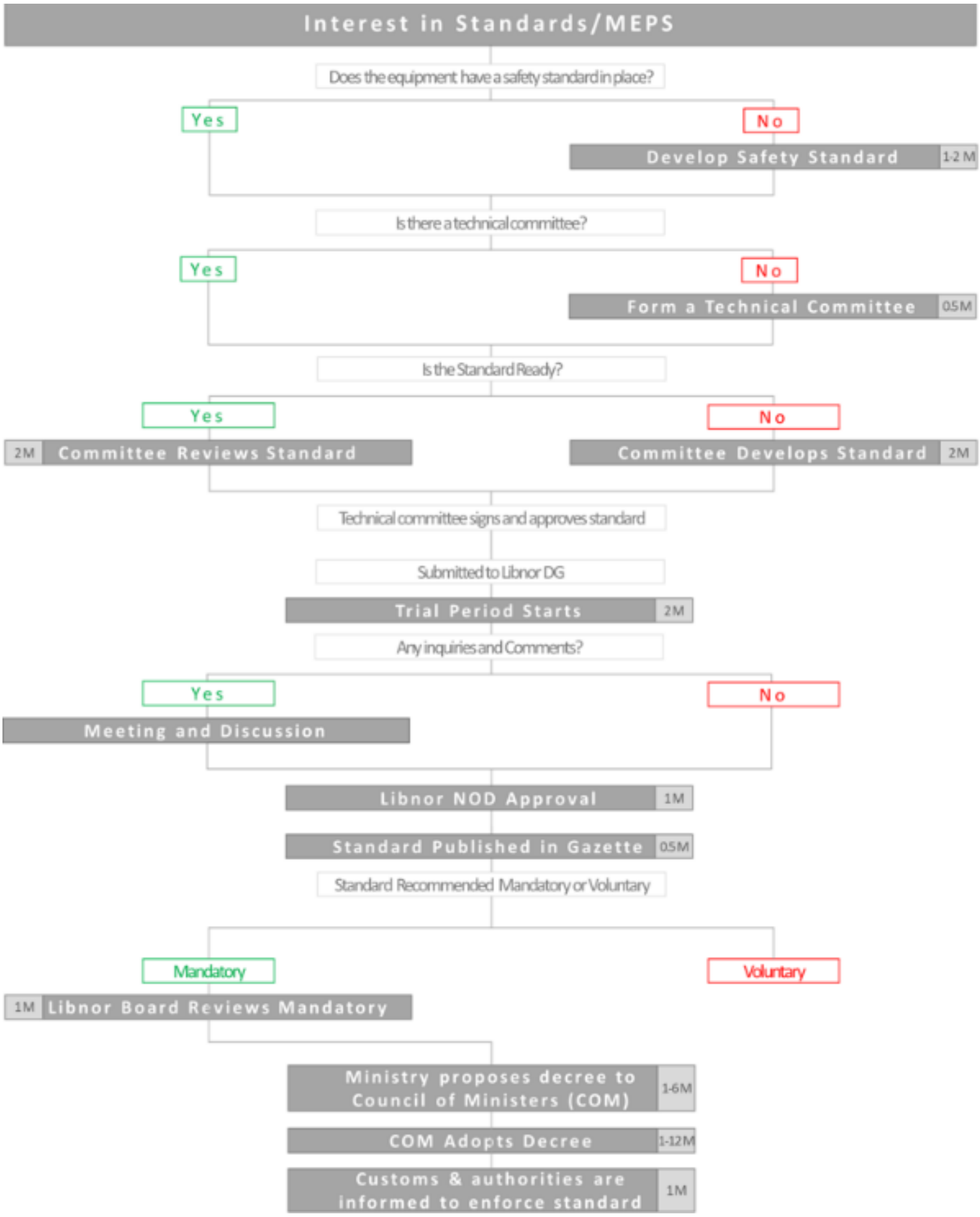


Figure 10: Process showing the adoption of MEPS and labels in Lebanon (Source: LIBNOR)

Figure 11 and Figure 12 show the process for the adoptions of international and non-international standards in Lebanon.

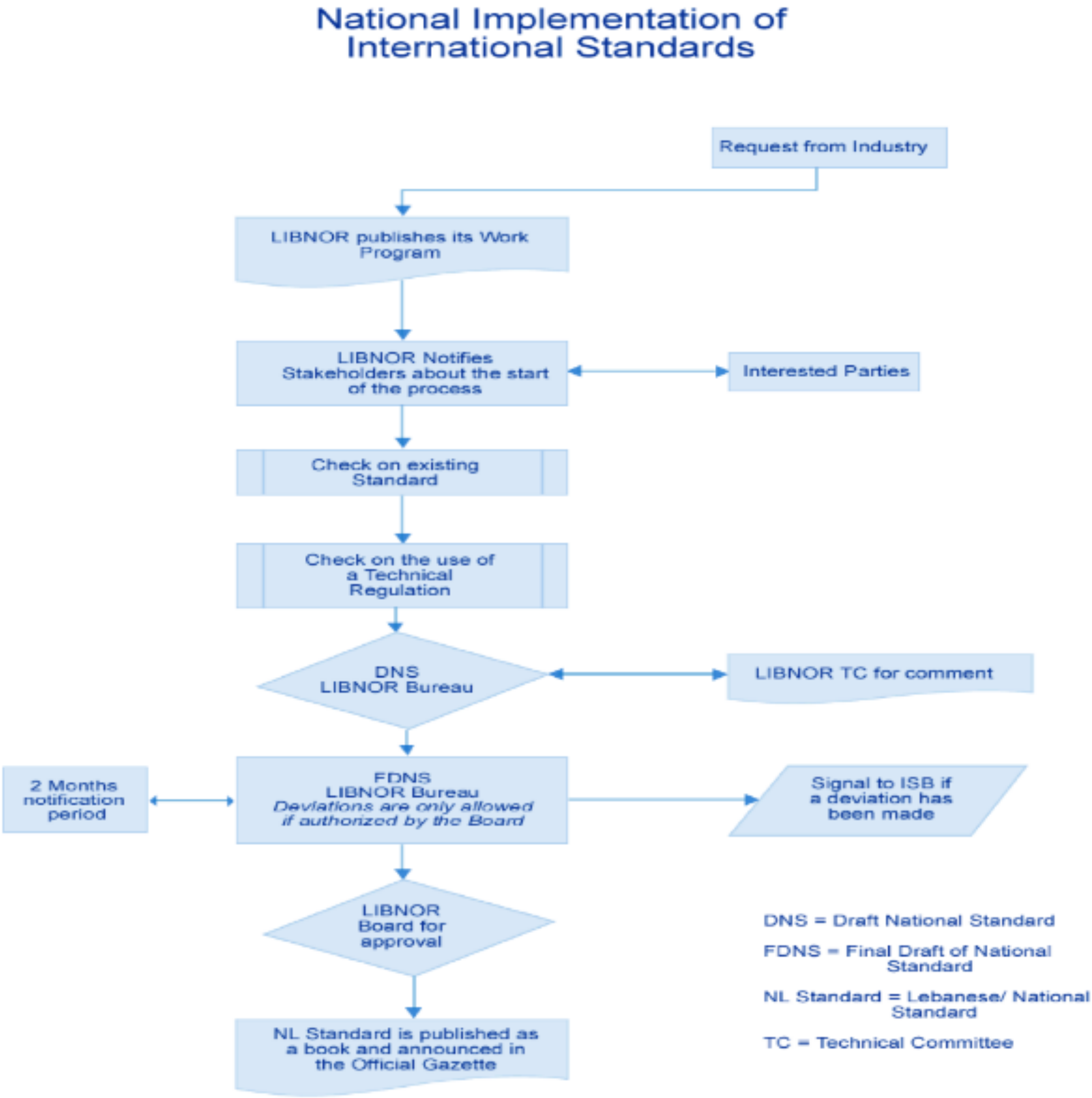


Figure 11: Process showing the adoption of international standards (Source: LIBNOR).

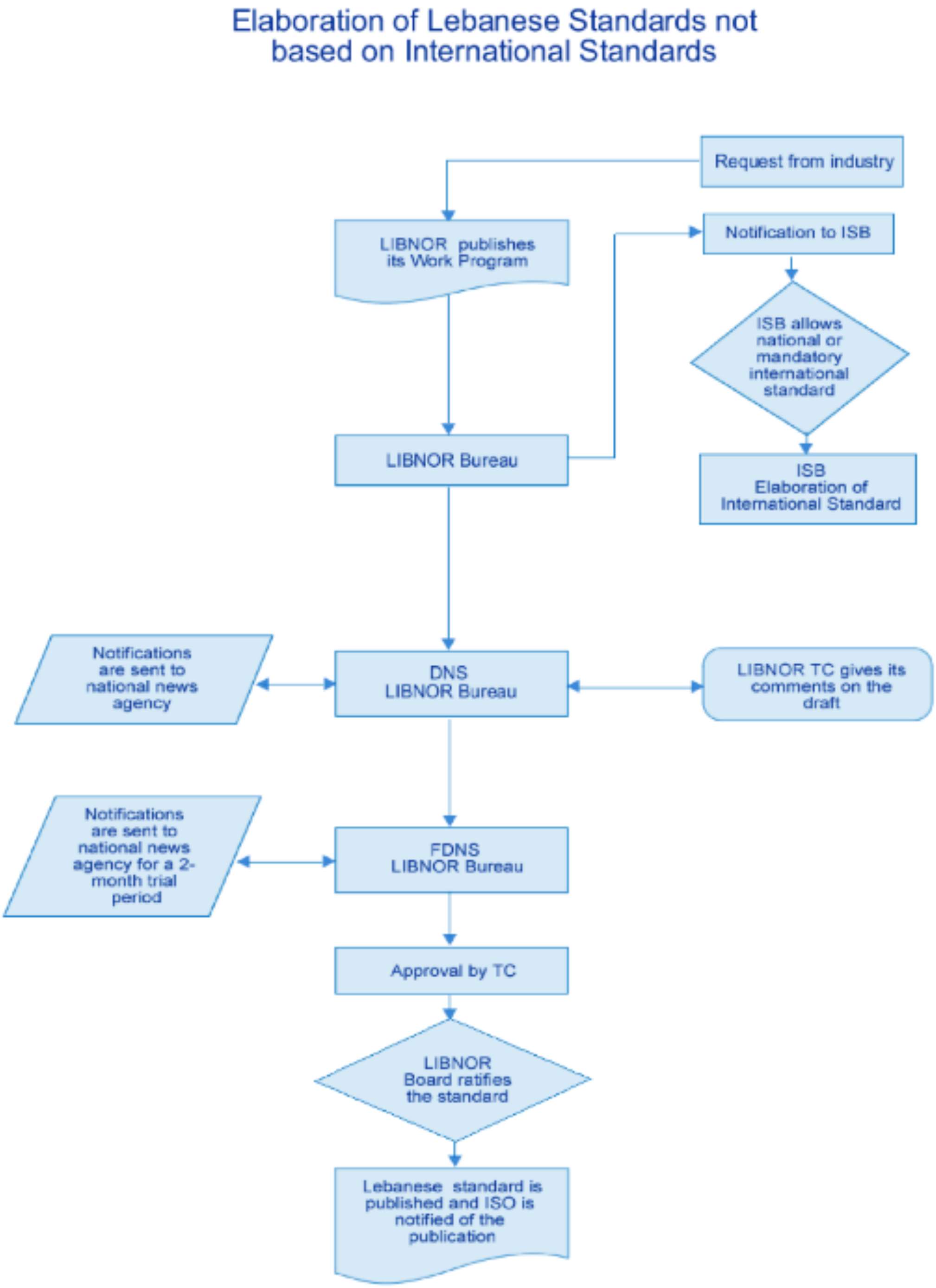


Figure 12: Process showing the adoption of national standards (Source: LIBNOR).

3.3 Proposed MEPS levels for electric motors and transformers

3.3.1 Electric motors Targets

In view of the energy performance standard harmonization, we suggest considering IEC 60034-30-1:2014 "Rotating electrical machines – Part 30-1: Efficiency classes of line operated AC motors (IE code)" as guidance for the electrical motors' energy efficiency levels. The minimum and maximum ambition scenarios suggest that the minimum energy performance standard is set at IE2 and IE3 levels, respectively as shown in

Table 13. The standard describes three energy efficiency categories IE1, IE2, and IE3. In addition, the minimum efficiency of the motors is defined for different rated motor power output in kW and for different number of poles or the corresponding motor speed.

Table 13 shows 29 motor power brackets starting from 0.12 kW to 200 kW. There are also 4 motor speed brackets, namely: 3,000, 1,500, 1,000, and 750 RPM corresponding to 2-, 4-, 6-, and 8-poles motor designs respectively. For example, a 1,500 RPM motor with a rated power output 0.75 kW would be rated as:

- Not rated if efficiency[10] is less than 72.1%
- IE1 - if the efficiency is greater than or equal to 72.1% but less than 79.6%.
- IE2 - if the efficiency is greater than or equal to 79.6% but less than 82.5%.
- IE3 - if the efficiency is greater than or equal to 82.5%.

This example is highlighted with a bolded red text in

Table 13. It shows that moving from IE1 (the current baseline in Lebanon) to IE2, we expect up to 7.5% efficiency improvement in this motor category while moving from IE1 to IE3, requires a 10.4% efficiency improvement.

Based on the current market trends and pricing in Lebanon, immediate transition towards IE3 would be cost prohibitive and may face significant challenges. As such, it is **proposed that the MEPS in Lebanon** is set at IE2 with progressive strengthening towards IE3. International best practices shall be reviewed every two years in order to set aspirational goals.

Table 13: Nominal energy efficiency requirements for 50 Hz motors.

Rated output power (kW)	Energy Efficiency (%)											
	No of poles / Synchronous speed											
	2-pole, 3000 RPM			4-pole, 1500 RPM			6-pole, 1000 RPM			8-pole, 750 RPM		
	IE1	IE2	IE3	IE1	IE2	IE3	IE1	IE2	IE3	IE1	IE2	IE3
0.12	45	53.6	60.8	50	59.1	64.8	38.3	50.6	57.7	31	39.8	50.7
0.18	52.8	60.4	65.9	57	64.7	69.9	45.5	56.6	63.9	38	45.9	58.7
0.2	54.6	61.9	67.2	58.5	65.9	71.1	47.6	58.2	65.4	39.7	47.4	60.6
0.25	58.2	64.8	69.7	61.5	68.5	73.5	52.1	61.6	68.6	43.4	50.6	64.1
0.37	63.9	69.5	73.8	66	72.7	77.3	59.7	67.6	73.5	49.7	56.1	69.3

[10] Efficiency is defined as the ratio between Motor's output power to its input power. It is typically measured according to IEC 60034-2-1:2014 (https://webstore.iec.ch/publication/121)

0.4	64.9	70.4	74.6	66.8	73.5	78	61.1	68.8	74.4	50.9	57.2	70.1
0.55	69	74.1	77.8	70	77.1	80.8	65.8	73.1	77.2	56.1	61.7	73
0.75	72.1	77.4	80.7	**72.1**	**79.6**	**82.5**	70	75.9	78.9	61.2	66.2	75
1.1	75	79.6	82.7	75	81.4	84.1	72.9	78.1	81	66.5	70.8	77.7
1.5	77.2	81.3	84.2	77.2	82.8	85.3	75.2	79.8	82.5	70.2	74.1	79.7
2.2	79.7	83.2	85.9	79.7	84.3	86.7	77.7	81.8	84.3	74.2	77.6	81.9
3	81.5	84.6	87.1	81.5	85.5	87.7	79.7	83.3	85.6	77	80	83.5
4	83.1	85.8	88.1	83.1	86.6	88.6	71.4	84.6	86.8	79.2	81.9	84.8
5.5	84.7	87	89.2	84.7	87.7	89.6	83.1	86	88	81.4	83.8	86.2
7.5	86	88.1	90.1	86	88.7	90.4	84.7	87.2	89.1	83.1	85.3	87.3
11	87.6	89.4	91.2	87.6	89.8	91.4	86.4	88.7	90.3	85	86.9	88.6
15	88.7	90.3	91.9	88.7	90.6	92.1	87.7	89.7	91.2	86.2	88	89.6
18.5	89.3	90.9	92.4	89.3	91.2	92.6	88.6	90.4	91.7	86.9	88.6	90.1
22	89.9	91.3	92.7	89.9	91.6	93	89.2	90.9	92.2	87.4	89.1	90.6
30	90.7	92	93.3	90.7	92.3	93.6	90.2	91.7	92.9	88.3	89.8	91.3
37	91.2	92.5	93.7	91.2	92.7	93.9	90.8	92.2	93.3	88.8	90.3	91.8
45	91.7	92.9	94	91.7	93.1	94.2	91.4	92.7	93.7	89.2	90.7	92.2
55	92.1	93.2	94.3	92.1	93.5	94.6	91.9	93.1	94.1	89.7	91	92.5
75	92.7	93.8	94.7	92.7	94	95	92.6	93.7	94.6	90.3	91.6	93.1
90	93	94.1	95	93	94.2	95.2	92.9	94	94.9	90.7	91.9	93.4
110	93.3	94.3	95.2	93.3	94.5	95.4	93.3	94.3	95.1	91.1	92.3	93.7
132	93.5	94.6	95.4	93.5	94.7	95.6	93.5	94.6	95.4	91.5	92.6	94
160	93.8	94.8	95.6	93.8	94.9	95.8	93.8	94.8	95.6	91.9	93	94.3
200 to 1000	94	95	95.8	94	95.1	96	94	95	95.8	92.5	93.5	94.6

3.3.2 Distribution and power transformers Targets

In view of the energy performance standard harmonization, it is proposed to consider IEC 60076-20:2017 as guidance for the Distribution Power Transformers' (DT) energy efficiency levels. In this standard, the DT energy efficiency is defined based on the levels of losses associated with its operation. IEC 60076 series, generally refer to the DT losses as either no load losses or load losses.

No-load losses do not vary with transformer loading and they are occurring right through the operation of the device. As such, it is important to keep the no-load losses to a minimum. These losses are primarily attributed to hysteresis losses in the core laminations and eddy current losses in the core laminations which contribute to almost 99% of the losses in addition to no-load current losses (I^2R), stray eddy current losses in core clamps, bolts and other core components, and dielectric losses.

Load losses, on the other hand, vary with the DT loading. They are largely attributed to heat losses and eddy currents in the primary and secondary conductors of the transformer. Heat losses (I^2R) in the winding materials are the main contributor.

DT energy efficiency brackets are divided into Level 1 and Level 2 as shown in Table 14 and Table 15 for "Fire Standard" and "Fire Safer" DTs as per IEC 60076-20:2017. In these tables, both the load losses (LL) and the no-load losses (NL) are defined and the combined impact on efficiency assuming 50% loading[11]. For example, a 250 kVA DT Level 1 LL and NL need to be less than 2,350 and 270 W, respectively to be considered as a Level 2 efficiency DT. This would result in a combined efficiency at 50% loading (EIA50) of 99.3%. A 250 kVA Level 1 DT will 99.11%. Hence, for this category of DTs, the efficiency improvements between Level 1 and Level 2 are modest at only 0.204%.

Based on the results from the scenarios assumptions and results, it is **proposed that the MEPS for DT in Lebanon should be set at level 1 and Level 2 efficiency levels, respectively following the load losses (LL) and no-load losses (NL) requirements** as set in Table 14 and Table 15. This is in line with EDL current specification for power transformers. Immediate MEPS may be set at level 1 with progressive MEPS strengthening towards level 2. International best practices shall be reviewed every two years in order to set aspirational goals.

Table 14: Fire standard distribution power transformers – Maximum load-losses (LL) and no-load-losses (NL).

Rated Power IEC 60076-1, kVA	Level 1			Level 2		
	LL, W	NL, W	EIA50, %	LL, W	NL, W	EIA50, %
≤25	900	70	97,640	600	63	98,296
50	1,100	90	98,540	750	81	98,926
100	1,750	145	98,835	1,250	130	99,115
160	2,350	210	99,003	1,750	189	99,217
250	3,250	300	99,110	2,350	270	99,314
315	3,900	360	99,152	2,800	324	99,350
400	4,600	430	99,210	3,250	387	99,400
500	5,500	510	99,246	3,900	459	99,426
630	6,500	600	99,294	4,600	540	99,463
800	8,400	650	99,313	6,000	585	99,479
1,000	10,500	770	99,321	7,600	693	99,481
1,250	11,000	950	99,408	9,500	855	99,483
1,600	14,000	1,200	99,413	12,000	1,080	99,490
2,000	18,000	1,450	99,405	15,000	1,305	99,495
2,500	22,000	1,750	99,420	18,500	1,575	99,504
3,150	27,500	2,200	99,424	23,000	1,980	99,509

Table 15: Fire safer distribution power transformers – Maximum load-losses (LL) and no-load-losses.

Rated Power IEC 60076-1, kVA	Level 1			Level 2		
	LL, W	NL, W	EIA50, %	LL, W	NL, W	EIA50, %
≤ 50	1,700	200	97,500	1,500	180	97,780
100	2,050	280	98,415	1,800	252	98,596
160	2,900	400	98,594	2,600	360	98,738
250	3,800	520	98,824	3,400	468	98,946
400	5,500	750	98,938	4,500	675	99,100
630	7,600	1,100	99,048	7,100	990	99,122

[11] DT efficiency is defined as the ratio between energy delivered and input; for EIA50, is the combined efficiency assuming 50% loading (i.e., the transformer is operating at full capacity for 50% of the time and 0-capacity for 50% of the time).

800	8,000	1,300	99,175	8,000	1,170	99,208
1,000	9,000	1,550	99,240	9,000	1,395	99,271
1,250	11,000	1,800	99,272	11,000	1,620	99,301
1,600	13,000	2,200	99,319	13,000	1,980	99,346
2,000	16,000	2,600	99,340	16,000	2,340	99,366
2,500	19,000	3,100	99,372	19,000	2,790	99,397
3,150	22,000	3,800	99,410	22,000	3,420	99,434

4 MEPS AND LABELS

4.1 Recommended MEPS and labels for each sector

The MEPS document could be established based on the U4E model regulation framework which has simple regulatory language that was developed to accommodate developing economies. The energy efficiency levels and test standards in the U4E model regulations follow the international best practices, especially that of the European Ecodesign. According to the current regulatory framework in Lebanon provides a 2-year grace voluntary period once the MEPS is signed into law.

4.1.1 Electrical motors

The Lebanese electric motors market is currently unregulated, however 95% of the electric motors on the market are IE1. The limited market supply of IE2 and IE3 motors in Lebanon results in a significant cost increase that is not necessarily substantiated by the costs of manufacture, but by supply chain and other factors. As such, it would be good to establish a phased approach to establish a transition approach where the MEPS is set at IE2 and is continuously updated to reach IE3. This could be done by establishing a technical review committee.

- Immediate consumer education / awareness campaigns + lifecycle cost assessment (CAPEX/OPEX)
- Issue MEPS at IE2 in 2025 (with 2 years voluntary grace period) based on U4E model regulations[12]
- MEPS revision in 2030 to consider IE3.

4.1.2 Distribution and Power Transformers

The Lebanese DT market is currently regulated only if the DT is connected to the EDF grid. It has to meet their criterial which is not necessarily a national MEPS. Moving from the current EDF minimum performance criteria to IEC 60076-20 level 1 (Minimum Ambition) would result in significant energy savings and emissions reduction and prime the market towards improved DT efficiency. Furthermore, it would accelerate the transition towards higher efficiency Level 2 transformers in later years. The following schedule is a recommended timeline for the implementation of MEPS for DTs in Lebanon

[12] https://united4efficiency.org/resources/model-regulation-guidelines-for-energy-efficiency-requirements-for-general-purpose-electric-motors/

- Immediate consumer education / awareness campaigns
- Capacity building on total cost of ownership for DTs[13].
- Issue MEPS at IEC 60076-20 Level 1 in 2025 (with 2 years voluntary grace period) based on U4E model regulations[14].
- MEPS revision in 2030 to consider intermediate energy efficiency level.
- MEPS revision in 2035 to consider transition to IEC 60076-20 Level 2.

4.2 Analysis of future MEPS and label levels per sector

In order to come up with recommendation for future MEPS and label levels in Lebanon, an in-depth market assessment of in-scope equipment currently sold in Lebanon has been carried out. For the assessment and the proposal of future MEPS and labels, the collected data has been analyzed for the energy mapping of appliances currently sold in the market and to develop a proposal for future label categories.

The market survey has established that the electric motors in Lebanon are largely IE1 (95%) with 4% IE2 and 1% or less IE3 electric motors. As described in section 2.2.1; a minimum ambition scenario would be to completely transform the market to adopt IE2 level electric motors and a maximum ambition scenario would be to transform the market towards IE3 level electric motors. Figure 13 shows the annual energy savings under different economic growth and energy efficiency adoption scenarios. The energy savings potential ranges from 32 GWh per year in 2025 to 71 GWh per year in 2050 under the baseline economic growth model assuming transition towards IE2. If the sector can move to IE3; the annual energy savings will increase from 60 GWh per year in 2025 to 135 GWh per year in 2050.

These estimates indicate the significant energy savings potential under the maximum ambition scenario; however, it is important to consider the tradeoff between initial cost and running cost. The market study has revealed that the IE2 motors are 40% to 592% more expensive than IE1 motors and that the IE3 motors are 144% to 700% more expensive than IE1. EDL has recently developed new electricity pricing that would encourage and incentivize energy efficiency for residential sector as follows:

- Bracket 1: 0-100 kWh: 0.1 USD/kWh
- Bracket 1: >100 kWh: 0.27 USD/kWh

For the commercial and industrial users, the proposed rate will be a fixed cost of 0.27 USD/kWh. This increase in electricity price will also greatly encourage users to adopt higher efficiency motors and ensure acceptable payback.

[13] https://united4efficiency.org/resources/a-guide-to-using-total-cost-of-ownership-when-purchasing-distribution-transformers/

[14] https://united4efficiency.org/resources/model-regulation-guidelines-for-energy-performance-requirements-for-distribution-transformers/

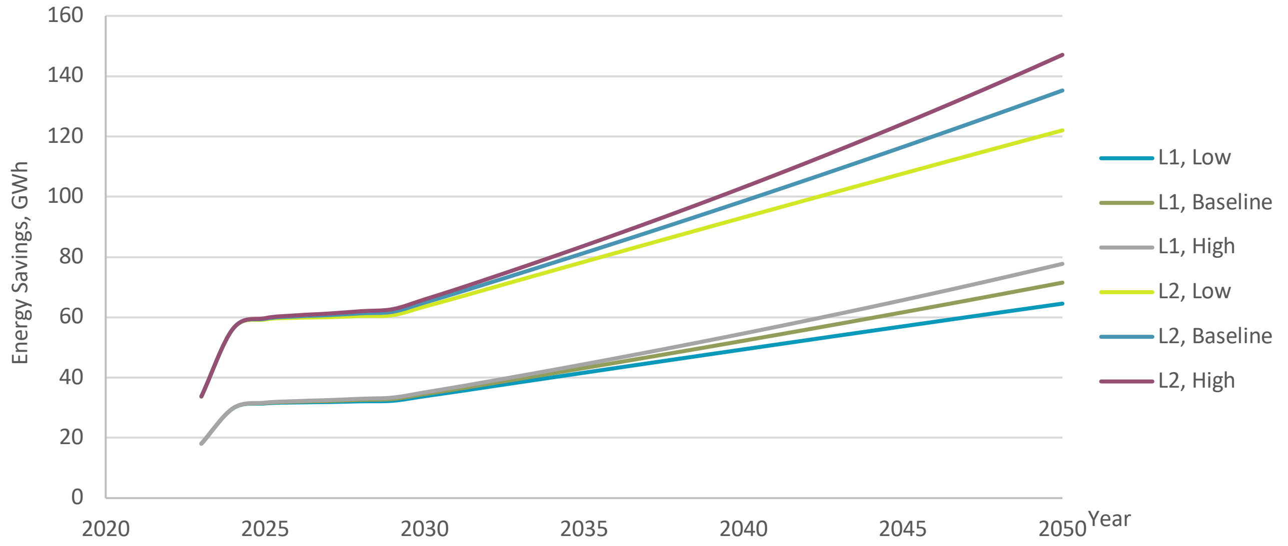


Figure 13. Electric motors energy savings potential under different economic conditions (Low growth, baseline, and high growth) with minimum ambition (L1) and maximum ambition (L2) scenarios.

Distribution and power transforms in Lebanon are currently procured according to the EDL specifications which are generally less ambitious that the IEC 60076-20 specifications. As described in section 2.2.2, a minimum ambition scenario (L1) would be to completely transform the market to adopt Level 1 according to IEC 60076-20 and a maximum ambition scenario (L2) would be to transform the market towards Level 2 efficiency of the same standard. Figure 14 shows the annual energy savings under different economic growth and energy efficiency adoption scenarios. The energy savings potential ranges from 12.5 GWh per year in 2025 to 20.9 GWh per year in 2050 under the baseline economic growth model assuming transition towards Level 1 DTs. If the sector can move to Level 2 DT, the annual energy savings will increase from 21.1 GWh per year in 2025 to 36.6 GWh per year in 2050. These energy savings would strongly support the Lebanese carbon emissions reduction. However, it is important to consider the tradeoff between initial cost and running cost. The local market study didn't include any higher efficiency cost. The United4Efficiency (U4E) initiative has developed tools for the evaluation of this tradeoff under the total cost of ownership[15] to support the informed decision during the DT procurement process.

[15] https://united4efficiency.org/resources/a-guide-to-using-total-cost-of-ownership-when-purchasing-distribution-transformers/

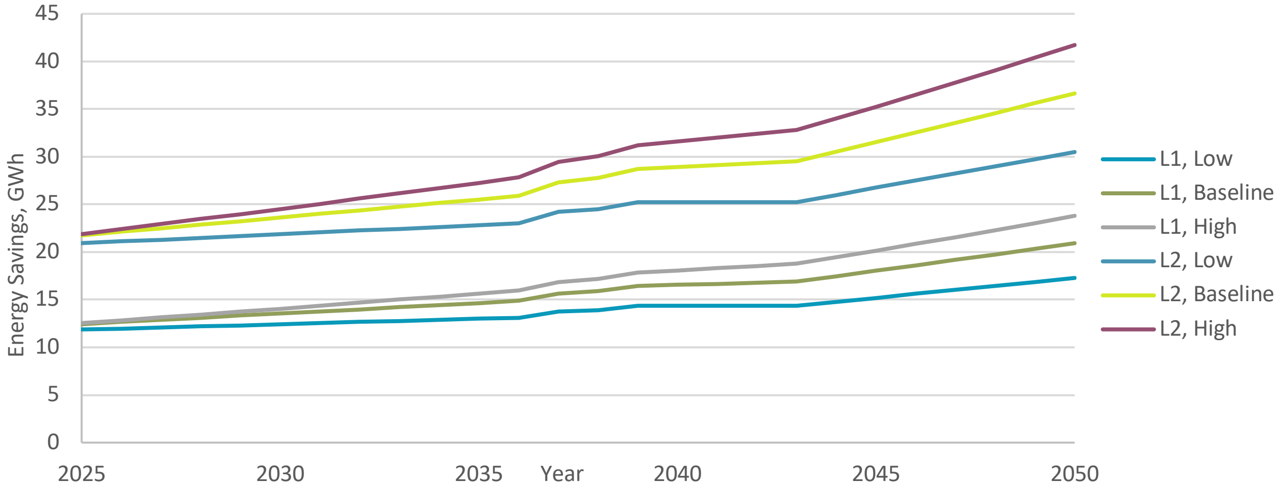


Figure 14. DT energy savings potential under different economic conditions (Low growth, baseline, and high growth) with minimum ambition (L1) and maximum ambition (L2) scenarios

4.3 Metrics

As mentioned above, MEPS and labels for the in-scope equipment are based on international standards. The following parts of this chapter provide a preview on the MEPS and labelling development and the applicable metrics.

4.3.1 Metrics for electrical motors

Single-speed electric induction motors energy efficiency is typically evaluated using IEC 60034-1, "Rotating electrical machines Part 1: Rating and performance", IEC 60034-2-1, "Rotating electrical machines – Part 2-1: Standard methods for determining losses and efficiency from tests (excluding machines for traction vehicles)", and IEC 60034-2-3, "Rotating electrical machines – Part 2-3: Specific test methods for determining losses and efficiency of converter-fed AC induction motors". It is important that electric motors manufactured and/or imported into Lebanon meet the energy efficiency criteria. IEC 60034-30-1:2014 "Rotating electrical machines - Part 30-1: Efficiency classes of line operated AC motors (IE code)" is considered as the best practice criteria for energy efficiency. This standard list 3 energy efficiency levels; "IE1", "IE2, and "IE3", as shown in Table 13.

Based on the preliminary market assessment; it is suggested that Lebanon adopt the International Efficiency Motors Class IE2 as a requirement[16]. This may provide the Lebanese market with the required adjustment period to adapt to the requirements of the International Efficiency Motors Class IE3 – the ultimate goal with the highest potential for energy savings.

All electric induction motors covered by the proposed regulation shall meet the minimum energy efficiency requirements as defined in the "IE2" category as shown in Table 13. the efficiency value shall be determined in accordance with the interpolation method specified in clause 5.4.5 of IEC 60034-30-1. The full-load energy

[16] This recommendation follows the united4efficiency electric motors model regulations Option B. https://united4efficiency.org/resources/model-regulation-guidelines-for-energy-efficiency-requirements-for-general-purpose-electric-motors/

efficiency of any individual motor, when tested at rated voltage and rated frequency in accordance with IEC 60034-2-1, shall not be less than the nominal efficiency declared by the manufacturer in technical documentation as well as on the rating plate, after allowing for the tolerance on the total losses according to IEC 60034-1.

Furthermore, manufacturers shall provide the following information for the motors covered by the proposed regulation, either on one or more rating plates, in accordance with IEC 60034-1, in accompanying technical documentation and free access websites. Letter symbols for units and quantities shall be in accordance with IEC 60027-1 and IEC 60027-4. Note that items a-c shall be durably marked on or near the motor's rating plate.

a) Year of manufacture.
b) Efficiency class (IE code).
c) nominal efficiency (η) at 100%, 75 % and 50 % rated load and voltage (UN); rated efficiency class as specified in IEC 60034-30 -1 e.g., "IE3".
d) Manufacturer's name
e) Manufacturer's serial number, Manufacturer's machine code
f) Number of phases, i.e., 3
g) Number(s) of the rating and performance standard(s) which are applicable.
h) Degree of protection (IP code) in accordance with IEC 60034-5.
i) Thermal class and the limit of temperature rise.
j) Class(es) of rating of the machine if designed for other than rating for continuous running duty S1.
k) Rated power output (kW).
l) Rated voltage(s) or range of rated voltage (V).
m) Rated frequency (Hz).
n) Rated current(s) or range of rated current.
o) Rated speed(s) or range of rated speed.
p) Maximum safe operating speed if less than that specified in section 9.6 of IEC 60034-1.
q) Rated power factor(s).
r) For wound-rotor induction machines, the rated open-circuit voltage between sliprings and the rated slip-ring current.
s) Maximum ambient air temperature, if other than 40 °C.
t) Minimum ambient air temperature if other than -15 °C.
u) The altitude for which the motor is designed (if exceeding 1,000 m above sea-level).
v) The approximate total mass of the motor, if exceeding 30 kg.
w) For motors suitable for operation in only one direction of rotation, the direction of rotation indicated by an arrow. This arrow need not be on the rating plate, but it shall be easily visible.
x) The connecting instructions in accordance with IEC 60034-8 by means of a diagram or text located near the terminals.

Table 16 below shows the energy and emissions associated with the establishment of MEPS for electric motors in Lebanon. Table 16 lists both the minimum and maximum ambition scenarios that relate to setting the efficiency to IE2 and IE3 efficiency levels, respectively. Furthermore, the table lists the different economic growth scenarios focusing on the baseline scenario. Electric motors are ubiquitous and used across multiple economic sectors. This analysis shows that moving to the higher ambition scenario may almost double the climate and economic benefit. Unfortunately, IE3 motors are currently significantly more expensive than IE2 motors in Lebanon and a phased transition from IE2 to IE3 could ensure that the market is primed and ready for real transformation.

Electric motors MEPS may result in up 65 to 147 GWh of annual energy savings which corresponds to 40 - 100 ktCO_2eq emissions by the year 2050. The cumulative energy and emissions reduction under the minimum ambition scenario are 1.3 TWh and 0.8 ktCO_2eq between 2025 and 2050.

Table 16: Energy and emissions savings in the year 2050 and cumulative between 2025 and 2050 for EM under the minimum and maximum ambition scenarios.

		Minimum Ambition Scenario	Maximum Ambition Scenario
Energy Savings in 2050, GWh	Low Economic Growth Scenario	65	122
	Baseline Economic Growth Scenario	**71.5**	**135**
	High Economic Growth Scenario	78	147
Emissions reduction in 2050, Mega Tons CO_{2eq}	Low Economic Growth Scenario	0.04	0.08
	Baseline Economic Growth Scenario	**0.05**	**0.09**
	High Economic Growth Scenario	0.05	0.1
Cumulative Energy Savings (2025 - 2050), TWh	Low Economic Growth Scenario	1.2	2.3
	Baseline Economic Growth Scenario	**1.3**	**2.4**
	High Economic Growth Scenario	1.3	2.5
Cumulative Emissions Reduction (2025 - 2050), Mega Tons CO_{2eq}	Low Economic Growth Scenario	0.78	1.47
	Baseline Economic Growth Scenario	**0.82**	**1.55**
	High Economic Growth Scenario	0.86	1.62

4.3.2 Energy efficiency metrics for distribution and power transformers

The efficiency of the distribution and power transformers are estimated based on the load and no-load losses based on the IEC 60076-1 test standard. the typical load curve for a distribution transformer is shown in Figure 15. The associated losses are then calculated for different designs for diverse 25 kVA DT as shown in Figure 16. The ideal case load scenario (50% continuous loading) can't differentiate between different DT designs, whereas the worst case pronounces the differences and can help the user select the most efficient DT. The IEC 60076-20 provides methods for efficiency and efficiency index calculation where the energy performance may be specified by maximum load-losses and maximum no-load losses and provides two levels of recommendations.

- Level 1 is for basic energy performance.
- Level 2 is for high energy performance.

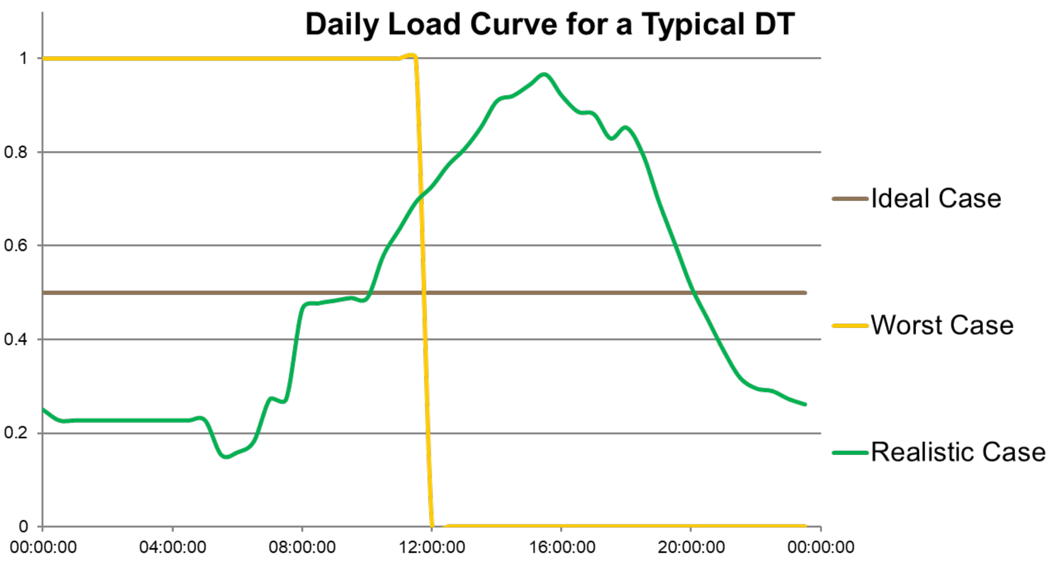
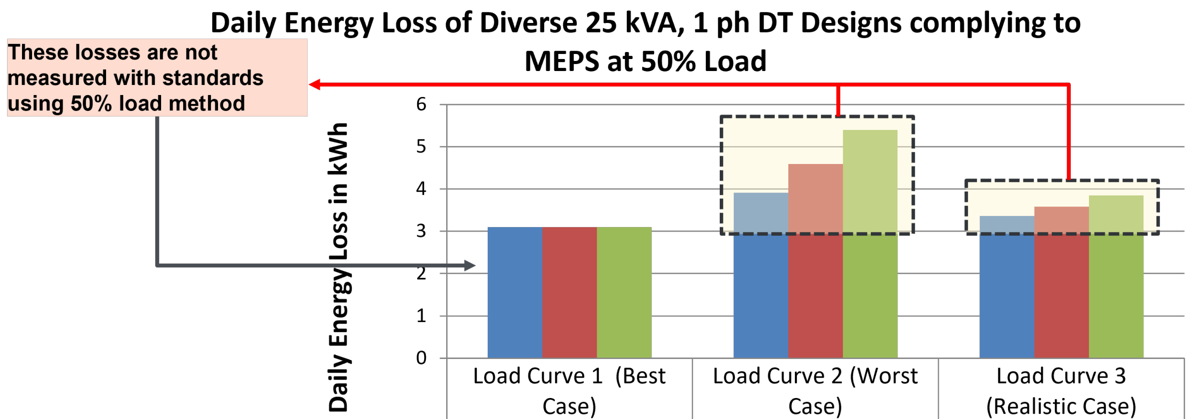


Figure 15. Daily load curve for a typical distribution and power transformer.



	Load Curve 1 (Best Case)	Load Curve 2 (Worst Case)	Load Curve 3 (Realistic Case)
Design A (NLL = 96 W, LL-144 W)	3.102	3.912	3.367
Design B (NLL = 66 W, LL = 264W)	3.102	4.587	3.588
Design C (NLL = 30W, LL= 408W)	3.102	5.397	3.854

Figure 16. Daily energy loss using different designs based on load curves of Figure 15.

Table 17 shows the energy and emissions associated with the establishment of MEPS for DT in Lebanon; the minimum and maximum ambition scenarios relate to setting the efficiency to Level 1 and Level 2 efficiency levels of IEC 60076-20, respectively. Furthermore, the table lists the different economic growth scenarios focusing on the baseline scenario. DTs are considered as large investment capital equipment with a long life (exceeding 20 years). The DT MEPS economic and climate impact is less pronounced than electric motors; however, it is important to ensure that the DTs are selected with the highest possible efficiency to minimize distribution losses.

DT MEPS may result in up 11.3 to 20 GWh of annual energy savings which corresponds to 7.4 – 12.9 ktCO_2eq emissions by the year 2050. The cumulative energy and emissions reduction under the minimum ambition scenario are 218 GWh and 140 ktCO_2eq between 2025 and 2050.

Table 17: Energy and emissions savings in the year 2050 and cumulative between 2025 and 2050 for DT under the minimum and maximum ambition scenarios.

		Minimum Ambition Scenario	Maximum Ambition Scenario
Energy Savings in 2050, GWh	Low Economic Growth Scenario	17	30
	Baseline Economic Growth Scenario	**21**	**37**
	High Economic Growth Scenario	24	42
Emissions reduction in 2050, Tons CO_{2eq}	Low Economic Growth Scenario	11,250	19,850
	Baseline Economic Growth Scenario	**13,600**	**23,850**
	High Economic Growth Scenario	15,500	27,200
Cumulative Energy Savings (2025 - 2050), GWh	Low Economic Growth Scenario	360	640
	Baseline Economic Growth Scenario	**410**	**720**
	High Economic Growth Scenario	450	780
Cumulative Emissions Reduction (2025 - 2050), Mega Tons CO_{2eq}	Low Economic Growth Scenario	0.24	0.41
	Baseline Economic Growth Scenario	**0.27**	**0.47**
	High Economic Growth Scenario	0.29	0.51