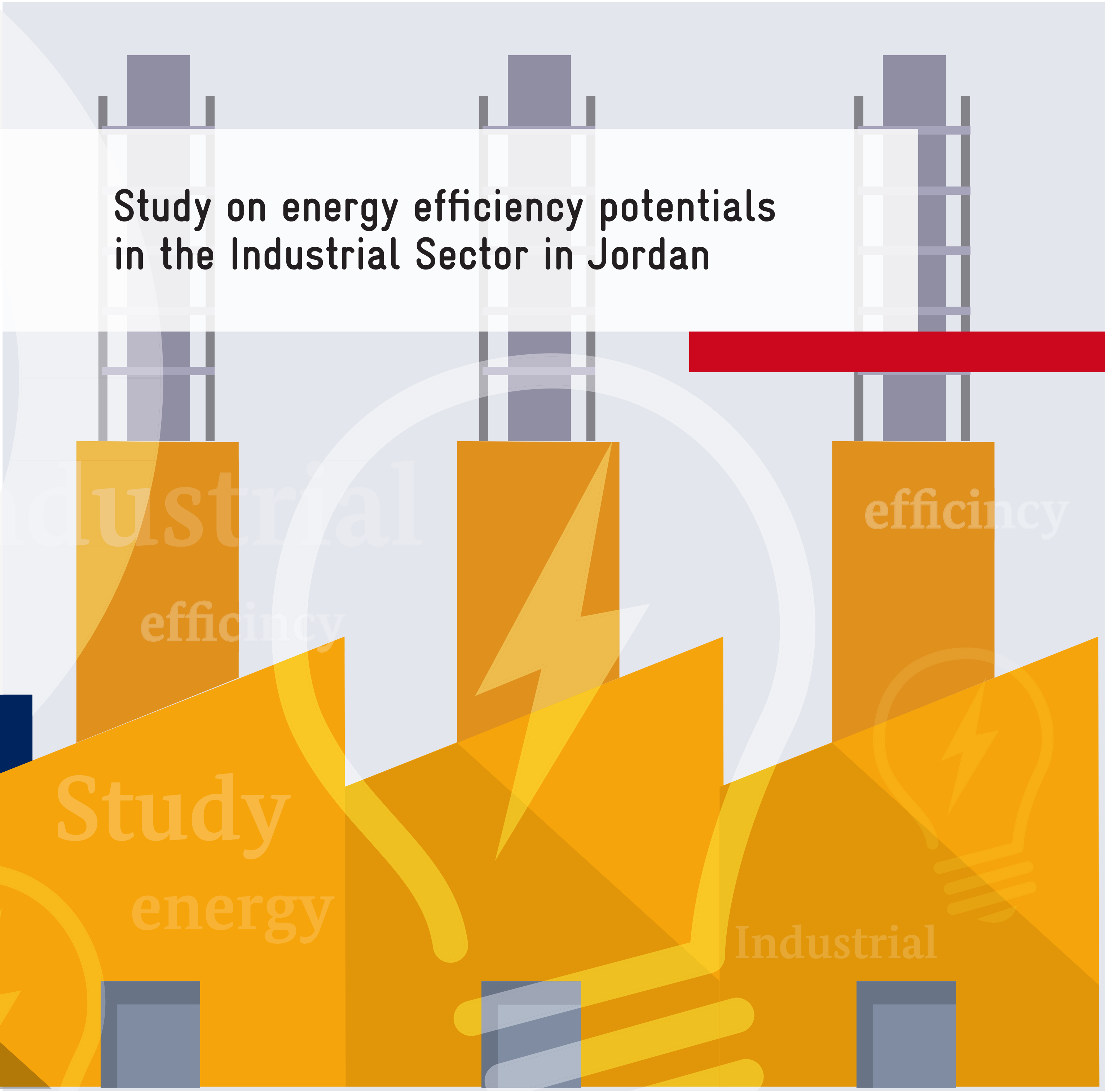
Study on energy efficiency potentials in the Industrial Sector in Jordan



with a focus on the rubber and plastic sector
and the food and beverage sector

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BAT	Best available technique
CIP	Cleaning in place
CO_2	Carbon dioxide
EIA	U.S. Energy Information Administration
EMAS	Eco-Management and Audit Scheme
EnEV	German energy saving regulation
EU	European Union
GDP	Gross Domestic Product
GHG	Greenhouse gases
JLGC	Jordan Loan Guarantee Corporation
JREEEF	Jordanian Renewable Energy and Energy Efficiency Fund
MEMR	Ministry of Energy and Mineral Resources
NAPE	German national action plan for energy efficiency
NEEAP	Jordan National Energy Efficiency Action Plan
NEPCO	Jordan National Electric Power Company
SME	Small- and medium-sized enterprises
toe	Ton of oil equivalent
VCM	vinyl chloride monomer

Executive Summary

This study aims to give an overview of energy efficiency potentials in the Jordan industry,by assessing the technical and economic feasibility of energy efficiency options. Therefore two high energy use and emission intense sectors, the rubber and plastic sector and the food and beverage sector, were analyzed in more detail. The study follows an comparative approach between Germany and Jordan.

As key indicators for the respective industries, e.g. energy consumption per employee or revenue are not yet available in Jordan, a direct comparison between the countries was not porssible. Some general conclusions could be found even though the sectors differ in their structure and size, as well as in their energy consumption patterns and degree of energy efficiency and are also very heterogeneous in themselves. Very positive experiences with energy audits have been made not only in Germany, but in Jordan as well. The implementation of energy audits or energy management systems has shown an increase of the amount of realized energy efficiency measures significantly. Also initiating energy efficiency networks has proven to be very successful in Germany and could be adopted in a Jordanian version.

This report suggests, in order to successfully strengthening energy efficiency in Jordan, tools like energy efficiency networks, energy audits and further organizational and political measures should be introduced and pursued further. For example expanding the National Energy Efficiency Action Plan by introducing further measures.

Energy Sector in Jordan

The industrial sector plays an important role for the overall Jordanian economy and accounts for about a quarter of the national GDP, which displays the relevance of studying the matter of energy efficiency in this sector.

Jordan is not an oil-producing economy and as a result imports 94 % of all national energy needs from neighboring Arab countries. Crude oil is the most prominent source of energy. 14 % of the total energy consumption was by the industrial sector in 2017. In the industrial sector the main sources of energy are electricity, heavy fuel oil, diesel and coal. Out of the main energy sources electricity dominates with 35 % of the total energy consumed in 2018. The recent development of increasing electricity prices re presents a challenge for the industrial sector. Electricity is a key factor of the production cost in most industries. Thus the price for electricity has an extremely high significance in some sectors, such as the plastic and rubber sector. In this subsector the costs for electricity account for more than half of the total production inputs costs, so that in total, when adding the fuel costs, the energy costs in this subsector account to 73 % of the total inputs costs.

The industrial sector, which gets most of its electricity from the national grid where the electrical traffic increases nearly every year, consumes about 25 % of all the used electricity in Jordan. Since Jordan imports most of their energy needs the country and its industry are highly affected by the fluctuation of international energy prices. The rise of energy prices results in a decreasing competitiveness and companies struggle to maintain their competitiveness in local and global markets.

The industrial sector in Jordan can be divided into the manufacturing and the mining sector. The rubber and plastic sector and the food and beverage sector are subsectors of the manufacturing sector. The plastic and rubber sector experienced a very fast growth in recent years and contributed to about 0.7 % of the national GDP of Jordan in 2017. Whereas the food sector contributed to about 2 % of the national GDP in 2017.

Improving the efficiency in energy use in the industrial sector is a key objective of the National Energy Strategy 2007–2020. The second version of NEEAP (2017–2020) has set a goal to reduce the energy consumption in the industrial sector by 12.7% by 2020.

The EU funded SwitchMed program proved that the potential of resource efficiency and cleaner production is given in the Jordan food and beverage sector by conducting 12 highly successful energy audits.

Potential Analysis

After giving an overview of the characteristics of energy sources and its consumption in the concerned subsectors of industrial production, the report focuses on a potential analysis in order to display possible improvements for energy efficiency. Therefore, both the private and the public level are discussed and potentials demonstrated within the scope of technical potentials. By incorporating a comparative benchmark- and a gap-analysis of Germany and Jordan, instruments to improve energy are displayed.

A) Technical potential analysis

There are different tools to assess technical potentials of a company level. Conducting an energy audit or implementing an energy management system has proven to be an effective way. Therefore in Germany, energy audits are mandatory for all companies that are not small- and medium-sized enterprises (SMEs).

Based on an energy audit organisational and technical improvements can be implemented, considering specific characteristics of each company and thus distinguishing the level of investment needed, the complexity of implementation and the saving potential. One successful way of lowering transaction costs and fostering energy efficiency for companies in Germany was the implementation of energy efficiency networks.

Technical potentials differ between the various industry sectors. But even within sub-sectors the technical potential varies widely from one type of company to another. Therefore, each company has to be examined individually. Nevertheless a sectoral approach to create energy efficiency networks can be favourable, especifically if companies from the same sub-sector are participating.

Best available techniques (BAT), publicized in reference documents by the European Union, describe the state-of-the-art technology, planning, building, maintenance, operation and decommissioning of installations to be used.These techniques can be applied to the Jordan context in order to facilitate energy efficiency in the industrial sector.

B) Gap Analysis

The gap analysis focuses on the institutional framework surrounding energy efficiency in both Germany and Jordan. Therefore, the development of energy efficiency, federal funding and support in Germany is being analysed. Based upon that, Jordan and German initiatives are compared. It is suggested, in order to foster energy efficiency potentials in the Jordan industry, to consider adjusting following policies to the Jordanian economic sectors:

- Establish legal obligations to perform energy audits
- Establish tax benefits for companies applying energy measurement systems (or energy audits)
- Subsidise best available technologies
- Rise awareness on the company level, for example through the introduction of energy efficiency networks

1. Background

Energy is a key element for economic growth that sustains industrial and commercial activities around the world. The fast global economic development and population growth are the key drivers behind the rapid growing in the global energy demand; consequently, the increased amount of greenhouse gas (GHG) emissions in the atmosphere is leading to global warming. Cutting carbon dioxide (CO_2) emissions, reducing air pollutions and combating global warming are at the top agenda of many countries. This requires developing green technologies and adopting energy policies to reduce relying on fossil fuel as main source of energy.

According to the World Energy Outlook 2018 the global energy demand is predicted to grow by more than 25% to 2040 with the current and planned policies in place.[1] This is driven by robust economic and population growth. It has also been reported that the dependence on coal has increased sharply by the developing countries in the last few years and will continue to increase unless these nations change their existing laws and strategies, particularly those related to GHG emissions, by adopting new sustainable pathway reliance on renewable energy and energy efficiency.

The deployment of renewable, exploring new technologies to mitigate carbon emissions, and optimizing energy consumption through implementing energy efficient technologies are crucial to achieve sustainability. Energy efficiency is the most feasible and fastest way to reduce greenhouse gas-emissions where its concept has been developed rapidly after the 1973 oil crisis. Since then, many energy efficiency initiatives have been adopted by many countries to enhance energy security through satisfying the energy demand via enhancing efficiency rather than increasing energy supply.

The Industrial sector is one of the key consumers of energy in any country. Adopting a holistic energy efficiency program would not only reduce the direct energy cost but rather it further has indirect benefits on operation and maintenance costs as well as on productivity in general. Energy auditing is the starting point in this long process where it is used to identify and quantify the areas of energy wastage and thus proposing cost effective measures to improve the efficiency.

Renewable energy resources have much lower environmental impact compared to conventional energy technologies and less costs accordingly. Most renewable energy resources are reliable, plentiful, and will potentially be very cheap when technology and infrastructure are improved. It includes solar, wind, geothermal, hydropower and tidal energy, as well as biofuels that are grown and harvested without fossil fuels.

[1] iea (2018)

1.1. Methodology of this study report

In order to understand and tackle the challenges stated above, this study report was issued. It wants to give an overview of energy efficiency potentials in the Jordan industry, by analysing two energy use and emission intense sectors in more detail. Therefore the rubber and plastic sector and the food and beverage sector were chosen as examples by transparent criteria (See chapter 2.4) in collaboration with JCI and GIZ.

The low carbon development potential those sectors was analysed by assessing the technical and economic feasibility of energy efficiency options. If on an operational level renewable energy options are applicable those were discussed in addition.

As agreed upon with JCI and GIZ the study was conducted as a desktop study. JCI facilitated data collection by provision of energy audit reports of previous projects and further sources.

2. Energy Sector in Jordan

Jordan is a non-oil producing country which suffers from inadequate supplies of natural resources including water, natural gas and crude oil. Only 6% of the total energy needs were produced locally in 2017 (from renewable energy, natural gas and crude oil sources). Consequently, 94% of the energy needs were imported from other neighbouring Arab countries.[2]

Table 1: Primary Energy Consumption in Jordan in 2017

Primary Energy Consumption (thousand tone of oil equivalent)							
Total	Imported Electricity	Renewable Energy	Natural Gas	Petroleum Coal	Coal	Crude Oil	Year
10009	13	515	3510	148	165	5671	**2017**
100%	0.1%	5.1%	35.1%	1.5%	1.6%	56.7%	**2017**

According to MEMR annual report 2017, the total primary energy consumed in Jordan in 2017 reached 10.09 million tons of oil equivalents (toe) as indicated in Table 1. The primary energy increased by 4.1% compared to 2016 consumption whereas the amount of crude oil products consumed in 2017 reached 5.67 million toe. Furthermore, the natural gas reached 3.51 Million toe in 2017.

As shown in Figure 1, crude oil is still the prominent source of energy which represents 56.7% of total primary energy consumed in Jordan. Crude oil is mainly used in transportation, electricity generation, and industry sectors. Followed by natural gas at 35.1% which is mainly used for power generation. It is worth mentioning that the renewable energy contributed by 5.1% of the primary energy mix in 2017, as per the recent expansion of RE projects in Jordan.

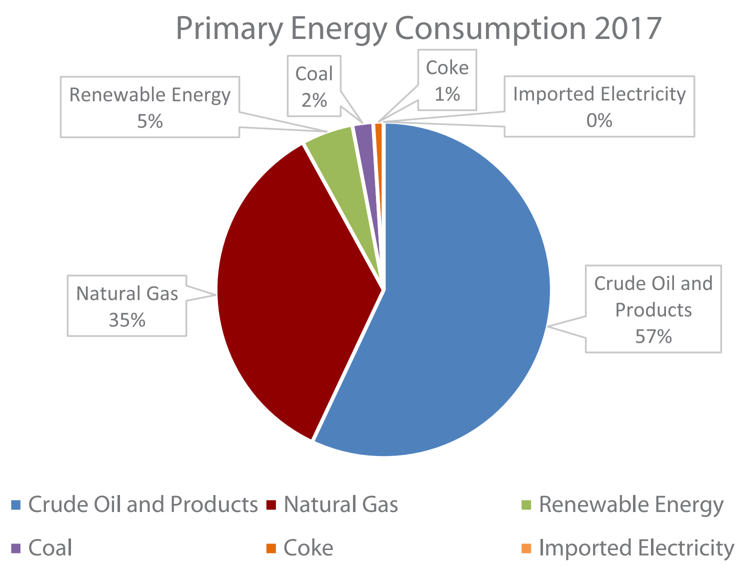

Figure 1: Primary Energy Consumption 2017

[2] MEMR(2017 (2015)

The final energy consumption in Jordan reached 6.89 Million toe in 2017 where 49% of it was consumed by transport sector, 23% by household, 14% by industry, and finally 14% by services and other sectors as shown in Figure 2 respectively.

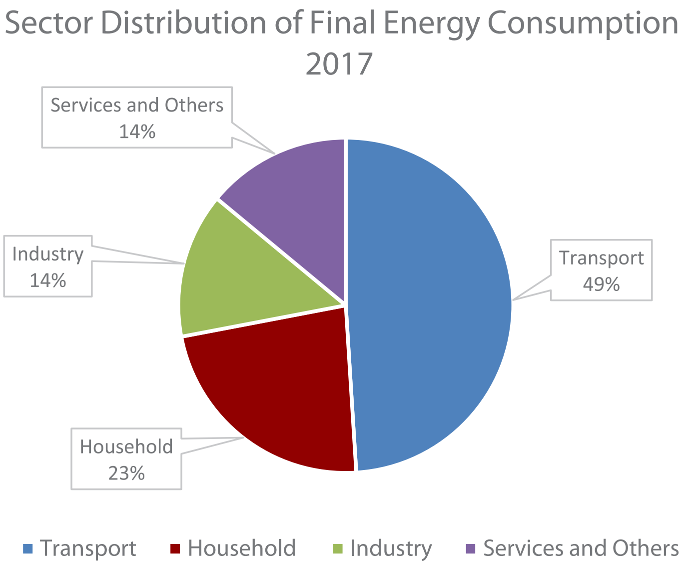

Figure 2: Sector Distribution of Final Energy Consumption in 2017

In its effort to manage and continue developing the energy sector, the Jordanian government unveiled in 2007 the National Energy Master Plan (2007–2020). This plan aims to maximize the use of domestic resources from the current 4% to 40% by 2020, particularly oil shale; encouraging energy conservation and awareness; generating electricity from nuclear energy, and promoting the development of renewable energy projects. It is projected that it will require a total investment of $18 billion in infrastructure development over the course of 13 years to meet these goals as shown in Figure 3.

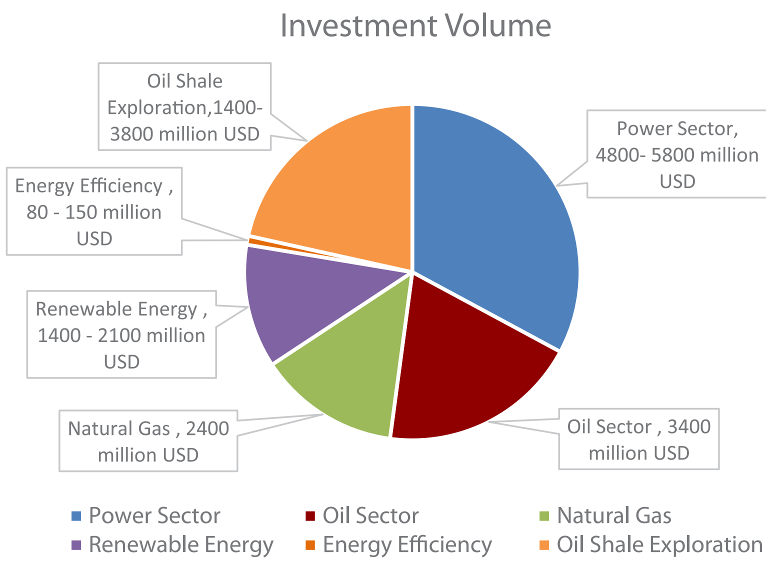

Figure 3: Investment volume required of each energy sector

According to the recent fact sheet published by MEMR in 2018, the construction of oil shale project has been started in the second quarter of 2017 and it is expected to start generating electricity from its oil shale-fired 470 MW power plant by 2020. While with regards to the renewable energy projects, around 1800 MW are either implemented or under current construction. No major progress has been achieved so far on the nuclear project. In the energy efficiency segment, MEMR has launched the energy efficiency plan 2018-2020 aiming to reduce the energy consumption by 20% in 2020. Energy Efficiency Standards and Regulations

2.1. Energy Efficiency Standards and Regulations

Jordan energy label certificate is mandatory where it is disseminated and implemented by the Jordan Standards and Metrology Organization (JSMO). In 2000, JSMO announced the launch of the Standards and Metrology Law No. 22. According to this law, subsequent series of regulations have been issued on energy labelling for products like refrigerating appliances, air conditioners and washing machines.

Starting from January 1, 2014, it became mandatory that all products must pass EE testing to get an energy efficiency certificate before being marketed in Jordan. The Jordanian Energy Label is the same as European Energy Label as shown in Table 2.

Table 2: EE labelling for products and appliances in Jordan

Product group	Energy Labeling
Air conditioners	EU 626/2011
Dishwashers	EU 1059/2010
Lamps (directional and LED)	EU 874/2012
Lamps (household)	EU 874/2012
Lamps (fluorescent)	EU 874/2012
Refrigerating appliances	EC 1060/2010
Television	EU 1062/2010
Tumble driers	EU 392/2012
Washing machines	EU 1061/2010

Improving energy efficiency is one of the main objectives of the National Energy Strategy 2007–2020. This aims to reduce oil imports, delay the need for new investment in electricity production facilities, and to reduce the carbon emissions impact on the environment. More specifically, the strategy aims to reach a target of 20% improvement in energy efficiency by 2020.

To facilitate meeting the energy efficiency target, the Jordan Law No. 13 on energy efficiency & renewable energy was adopted in 2012. In addition, the Jordanian Renewable Energy and Energy Efficiency Fund (JREEEF) was launched in the same year and started its first period of operations (2012–2014). In 2018 MEMR launched the energy efficiency plan 2018-2020 aiming to reduce energy consumption by 2000 GWh with a total cost of JD 700 Million. The implementation mechanism includes 26 measures that will cover (residential, commercial, industrial, transport, pumping station and street lighting sectors).

In order to help meeting the national energy efficiency target, the National Energy Efficiency Action Plan (NEEAP) was developed as a national document that summarizes all national energy efficiency efforts that are done on a local level and draws the road map for implementation. The first version of this document was developed in 2011 for the period 2012–2014, while the second NEEAP of Jordan is to cover the period 2017–2020.

The first Jordan NEEAP (2012–2014) included eleven key measures mainly to improve the lighting efficiency by using energy efficient lamps, installation of solar water heaters, as well as using energy labelling for home appliances. While some of these measures targeting the residential sector are expected to create spill-over effects on the industrial and commercial sectors (particularly on lighting and appliances), specific measures have been stipulated for these sectors. For the industrial sector, Mobile Energy & Environment Clinics were put in place to offer energy and water efficiency audits as well as advisory services on reduction measures. For the commercial sector, advocacy work to stimulate replacement of fluorescent lightbulbs with conventional ballast with those with electronic ballasts (and thus lower power consumption) has been put in place. [3]

Overall, the measures included in the first NEEAP have set out the target to deliver 7.6% reduction in energy consumption by 2014, which equalled to around 806 GWh.

The second NEEAP (2017–2020) has set a target to reduce the energy consumption by 17.6% by 2020, through implementing 35 key measures which are specified by sectors. The industrial sector is targeted by an energy efficiency programme where energy audits will be conducted through visits at the respective factories. Based on these audits, most effective measures to enhance energy efficiency will be identified for each factory and subsequently implemented. It is expected that a total of 30 audits will be conducted, leading to a reduction in electricity consumption of 383 GWh over the four target years of the plan, creating fiscal savings of a total of 53 mio. JD for the users.[4]

[3] NEEAP 2012–2014
[4] NEEAP 2017–2020

Certain measures targeting other sectors can also be expected to create spillover effects on the industrial sector. This includes the programme to replace fluorescent light tubes by LEDs in commercial buildings (aimed at replacing 250,000 lighting units). Moreover, some measures targeted at the residential sector, particularly the introduction of energy labels for home appliances (including those that are also used in commercial contexts, such as air conditioners) can also be expected to create spillover effects on the industrial sector as well.

Other measures that are stipulated by the second NEEAP include revisions of building codes to enhance thermal insulation in the residential and tertiary sectors, changes in lighting system in public buildings, and a revolving fund to incentivise replacement of incandescent lightbulbs with LEDs.

Implementing the proposed 35 measures in all targeted sectors is supposed eventually to reduce energy consumption by 1975 GWh in 2020.

2.2. Renewable Energy Standards and Regulations

Jordan has significant potentials in solar and wind energy. In its efforts to reduce dependency on fuel imports, Jordanian governments started exploring alternative sources of energy. Guided by the National Energy Strategy established in 2007, they decided to place more emphasis on the utilization of renewable energies and on energy efficiency. The share of renewable energy in the total electricity mix was planned to reach 7% by 2015 and 10% by 2020. According to NEPCO annual report 2017, the available capacity from renewable energy sources reached around 600 MW by 2017.

In 2012 the Jordanian government issued the Renewable Energy and Efficiency Law, which arranged the model for private sector participation in renewable projects, marking a remarkable shift in renewables development. In order to have more competitive biddings, the Jordanian government reformed Jordan's renewables framework in 2015 to facilitate selecting winners under renewable power purchasing agreements based on the lowest tariffs offered after meeting the project's technical and generating requirements. The impact of this law was profound as per the big number of projects implemented where around 1800 MW renewable energy projects are completed or under construction.

On a small scale, JREEEF has signed agreements with local banks along with the Jordan Loan Guarantee Corporation (JLGC) to finance renewable energy projects. These agreements will help in speeding up the implementation of projects supported by the JREEEF through providing the necessary funds to individuals and small- and medium-sized enterprises, mostly in the industrial and tourism

sectors. For residential sector, JREEEF launched a project to bring solar hot water to all parts of Jordan.
The project aimed to install 20,000 solar water heaters between 2013 and 2019 by covering 50% of their cost. (To date, 13,000 have been already installed).

Renewables development has already made a significant impact on the country's energy balance according to the Ministry of Energy and Mineral Resources (MEMR) where the contribution of renewables to primary energy consumption rose up from 130,000 toe in 2011 to 160,000 toe in 2015. Solar energy accounted for 52.4% of the energy produced locally in 2015. Meanwhile NEPCO mentioned in its annual report 2017 that renewables accounted for 4.6% of total domestic and imported electricity generation in Jordan, with wind generation reached 449 GWh in 2017, and solar-powered generation increased significantly to 591 GWh from the transmission network and 303 GWh from the distributed network by 2017.[5]

2.3. Energy in the Industrial Sector

The main sources of energy used by the industry in Jordan are electricity, heavy fuel oil, diesel, and coal. As depicted in Figure 4,electricity is still the dominant source of energy used in industrial sector where it represented 35% of total energy consumed in 2018, followed by diesel and coal with 17% each, and 16% by fuel oil consumption while the remaining energy sources are either 10% or below.

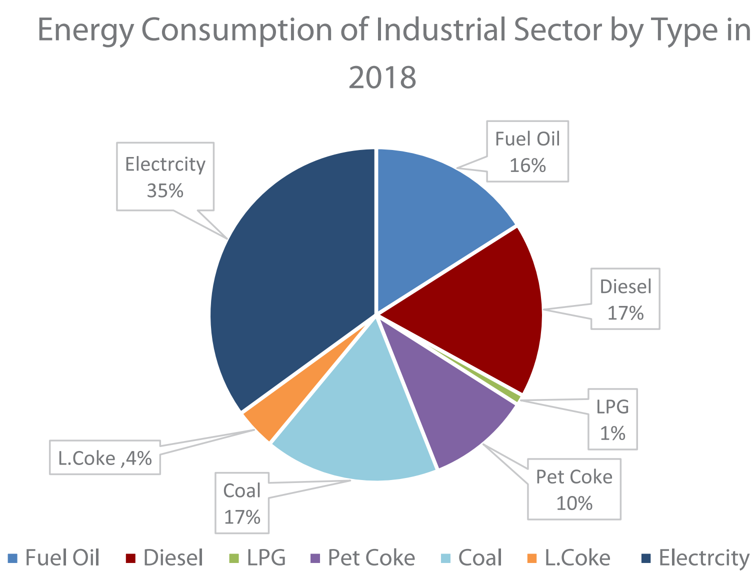

Figure 4: Energy Consumption of Industrial Sector by Type in 2018 [6]

[5] NEPCO (2017)
[6] MEMR (2019)
[7] JMEMR Report (2012)

2.3.1. Energy Consumption vs Production Capacity

Figure 5 illustrates the actual production capacity relative to design capacity ratio as reported by MEMR industrial survey in 2012.[7] About half of the firms surveyed are being operated at less than 60% of their designed capacities; which would increase specific energy consumption per unit of production. When the actual production is closer to the designed capacity the specific energy consumption would be lower and the production process is more economically efficient.

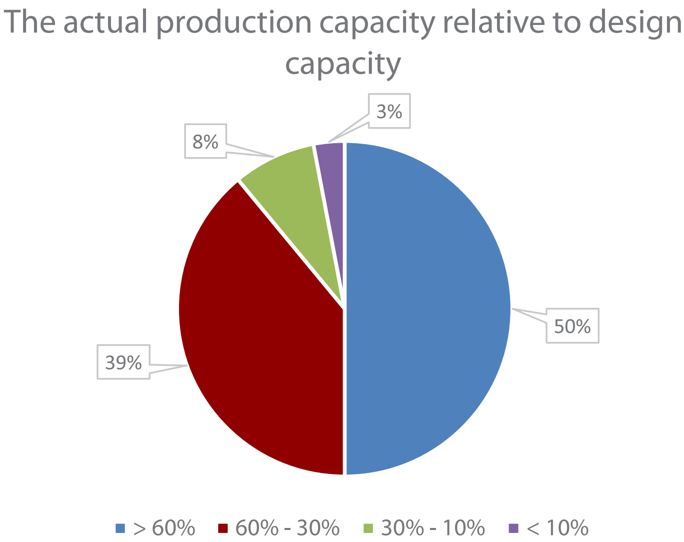

Figure 5: The actual production capacity relative to design capacity

2.3.2. Energy Prices in Industrial Sector

Jordan is an oil importing country where Jordanian industries are affected significantly by the fluctuation of energy prices, especially those industries for which energy is a prominent part of its input cost. Thus, any significant rise in energy prices would affect those industries substantially in their ability to maintain their competitiveness in the local and global markets. On the other hand, a significant rise in energy prices would induce the industrial sector to look for ways to optimize its energy consumption and to find other cheaper energy sources..

Fuel Tariff

Fuel prices in Jordan are calculated monthly based on international prices, plus other costs including shipping and taxes. As shown in Table 3, the Diesel/kerosene tariff rate per litre varied from 0.465–0.54 JD with an average increment of 16.1% in 2017. The tariff rate for fuel oil for industry also increased during 2017 with an average of 11.4% from 314 to 350 JD per ton. On the other hand, natural gas witnessed low increment by 4.7% in 2017. [8]

[8] JMEMR Report (2012)

Table 3: Fuel tariff for industrial sector in 2017[9]

Item	Unit	2017
Kerosene	JD/Litre	0.465-0.54
Diesel	JD/Litre	0.465-0.54
Liquefied Gas 12.5kg	JD/Cylinder	7
Liquefied Gas 50kg	JD/Cylinder	29-37
Natural Gas/Industry	JD/MBTU	5.86-7.06
Fuel Oil/Industry	JD/ton	293.25-350.06

Fuel Storage Capacity for Industrial Sector

Jordan Petroleum Refinery reported that the capacity of liquid fuel storage of major industrial firms in Jordan is 402,350 tons. The industrial sector survey conducted by MEMR in 2012, showed that the surveyed firms had storage capacity of 5, 765 ton of fuel oil of which represented 23.5% of its annual consumption as summarized in Table 4. While the storage capacity for diesel fuel was only 6.4% of the annual consumption of the surveyed facilities. This is because of diesel consumption has increased rapidly from 2005 to 2011 before it decreased again in 2012. The increment in consumption was not accompanied with increase in storage capacity as per diesel fuel is widely distributed unlike fuel oil or LPG. The storage capacity can be used by industrial facilities as a tool to store huge amounts of fuel when energy prices are low so that its competitiveness in the market is enhanced when energy prices go up again.

As a consequence of the introduction of coal after 2012, some of this storage capacity has become redundant, when a considerable number of industries switched to coal from fuel oil and diesel. There is no official data on the storage capacities for coal since it is usually stored in closed hangars or in open areas. However, it can be estimated from some of the main consumers of coal (cement and steel industries) that it is about 25% to 50% of the annual consumption.

Table 4: Summary results of surveyed industries of fuel consumption and storage capacity[10]

Fuel Type	Consumption Ton	Storage Capacity	Tons Storage/ Consumption %
Fuel Oil	24541	5765	23.5%
Diesel	22054	1412	6.4%
LPG	4288	1194	27.8%

[9] MEMR (2017)
[10] JMEMR Report (2012)

Industrial Sector Electricity Consumption

The industry sector in Jordan is facing a difficult period because of the rise in electricity prices as per electricity is a major input for its production where it consumes about a quarter of the total electricity in Jordan. The industry sector is the second largest contributor in GDP after services sector with a rate of 24%

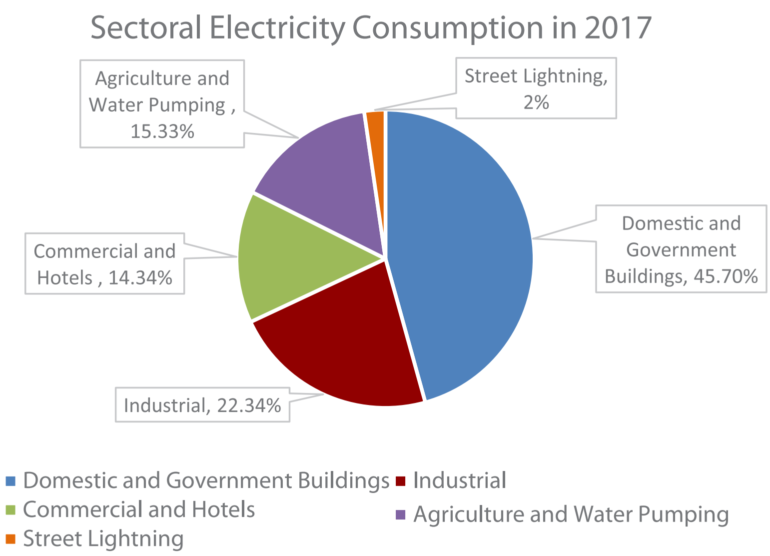

Figure 6: Sectoral Electricity Consumption 2017[11]

As shown in Figure 6, the industrial sector is the second largest sector in terms of electricity consumption after the residential sector and accounted for 22.34% of the total electricity consumed in Jordan. Electricity is a key factor of the production cost in most of industries, mainly in plastic and printing & packaging subsectors, where electricity represents more than 50% of the production inputs cost.

The high rise in electricity prices has led to higher production cost and thus reduced competitiveness of many Jordanian industries when compared to neighbouring countries in both domestic and foreign markets, in addition to the negative impact on attracting foreign investments. Therefore, many industrial facilities decided to close because of the high rise in electricity prices, which led to losing thousands of jobs as a result of the closure of these factories.[12] For instance, if we compare the electricity prices of industrial sector in Jordan with Saudi Arabia, we can notice that prices in Jordan are higher between two to eight times depending on the industry size and time of consumption.

As demonstrated in Figure 7, electricity prices for some industrial sectors have increased more than fivefold since 1992. The major increase happened in 2011 after a decline in natural gas imports from Egypt until complete cutoff in 2014. The imported gas was mainly used for electricity generation in Jordan, which

[11] NEPCO (2017)
[12] NEPCO (2017)

caused the power generation plants to fire fuel oil instead of gas, which is much more expensive and less efficient. Even if we compare the current electricity prices for industrial sector with that applied after the Egyptian gas cutoff and the high rise in electricity prices in 2012, the electricity prices in 2017 increased between 33% to 42% in small, medium and large industries and 4%-8% in mining industries.

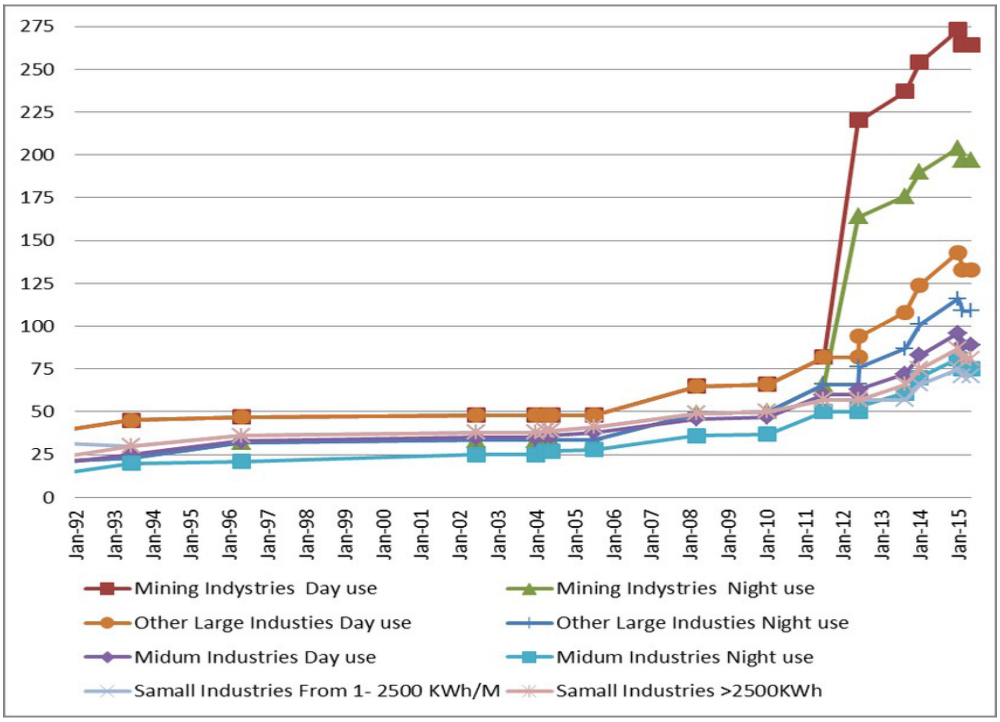

Figure 7: The historical electrical tariff (in fils:1/1000 JD) of the different industrial sector [13]

Electricity tariff for the industrial Sector

The industrial sector relies on the national grid for most of its electricity consumption. On-site electricity generation is rare due to the fluctuation of energy prices and hence the electrical tariff is increasing nearly every year. As shown in Table 5, the tariff is divided into three categories depending on the size of an industrial facility: small, medium and large.

- Small industries: This tariff is applied for industrial consumers supplied through low – voltage networks for single and three phases all over the kingdom, with maximum loads not exceeding 200 kW.

- Medium industries: The tariff is applied for industrial consumers supplied from medium -voltage networks (33, 11, 6.6 kV) or supplied from low – voltage networks with load level exceeding 200 kW.

[13] Al-Rub et al. (2016)

- Large industries: The tariff of electrical energy supplied to principal Consumers who are directly supplied from 132 kV Networks via main substations. [14]

For small industries, a flat tariff is applied, with different rates for the first 10000 kWh per month and for higher consumption above 10000 kWh. While for medium industries, two types of rates are applied for day and night electricity consumption in addition to a peak charge for any connected load in kW from 5 pm to-8 pm during the winter or 7 pm to 10 pm during summer. The same concept is applied for large industries but with different rates. With the current over capacity of electricity generation system in Jordan, the peak charges must be revisited to reduce the burden on the industrial sector.

Table 5: Electricity tariff for industrial sector in 2017 [15]

Sector	Size/Type	Flat Rate Tariff	Peak Load	Day Rate	Night Rate
		JD/kWh	JD/kW/Month	JD/kWh	
Large Industries	Mining	-	2.98	0.237	0.170
	Other	-	2.98	0.124	0.109
Medium Industries		-	2.00	0.089	0.075
Small Industries	1-10000 kWh	0.071	-	-	-
	>10000 kWh	0.081	-	-	-

2.4. Sectoral Analysis

The industrial sector is an important part of Jordan's economy and contributes directly to about a quarter of the national GDP. This sector consumes 17% of Jordan's primary energy consumption and 22% of Jordan's electricity consumption. [16] The industrial sector in Jordan is divided into the manufacturing and mining sector.

The manufacturing sector includes: Leather and garments, pharmaceutical industries, medical supplies, chemicals, cosmetics, plastic and rubber industries, engineering and electrical industries, information technology, wood and furniture industries, construction industries, the food industries, packaging, paper and cardboard, and office supplies industries.

The mining sector in Jordan consists of two parts; the first part is the mineral extraction industries which include Potash, Phosphate, Salt, Calcium Carbonates, Travertine, Silica, and other quarries and mines products. The second part is the mineral manufacturing industries which include fertilizers and chemical acids,

[14] JEPCO (2019)
[15] JEPCO (2019JMEMR Report (2012)
[16] MEMR (2018)

white cement, lime and cement, rock wool, china ceramic tiles and sanitary ware silicate bricks.

There are ten key subsectors under both manufacturing and mining sectors as listed in Table 6 below:

Table 6: Energy Consumption for Industrial Sub-sectors in Jordan

Sub Sector	Energy cost of total production inputs cost (exclude raw material)			# of Industrial Facilities	# of employees	Production 2015
	Electricity	Fuel	Total energy			Million JD
Construction	25%	54%	79.0%	183	9,258	1025
Plastic and Rubber	59%	14%	73.0%	201	6,893	526
Mining	34%	45%	79.0%	31	10,753	1,153
Leather and Garments	43%	21%	64.0%	183	49,120	621
Furniture	30%	46%	76.0%	88	3,736	275
Engineering	27%	28%	55.0%	421	29,433	2145
Therapeutic	11%	11%	22.0%	75	8,318	1,029
Chemical	19%	31%	50.0%	204	13,246	4,140
Food	13%	34%	47.0%	473	38,301	3,668
Printing and Packaging, Paper	48%	36%	84.0%	241	10,989	611

As it can be noticed from Table 5, energy is a prominent element of the production input cost of many industries, such as: construction, mining, plastic, furniture, and printing and packaging. Between 70 and 85% of the production input cost is coming from energy in those industrial subsectors. Furthermore, plastic and food are among those industries that have witnessed fast growth in the number of established facilities in Jordan in addition of having high potential for EE improvements compared to the other industries.

2.4.1. Rubber and Plastic Industry

The plastic and rubber industry in Jordan has experienced very fast growth where it is one of the most important industries that contribute directly and indirectly to many commercial and industrial activities in our lives.[17]

The Plastic and Rubber sector includes the following core products:

- Rubber tires, tires coating and rubber tires and tubes.
- Rubber products, panels, plates, rods, tires and tubes or belts

[17] Industry - Jordan Investment Commission (2018)

- Panels, plates, tapes, rolls, hoses, plastic pipes and fittings.
- Health plastic wares, baths and shower baths, sink tubs and others.
- House wares and Plastic cosmetics.
- Fiber glass products.
- Plastic toys, games and accessories.
- Plastic farm tools.
- Sponge products.

As demonstrated in Table 7 that plastic and rubber industry contributed to around 0.7% Jordan's GDP through exporting products with a total amount of 179 million JD in 2014

Table 7: The importance of the Rubber and Plastic sector [18]

Year 2014	
Capital size	87 million JD
Jordan GDP	25,437 million JD
Export volume	179 million JD
Facilities number	503
Size of employment	7327

Electricity/Fuel Usage in the Rubber and Plastic Sector

This sector is one of the sectors with the highest consumption in electrical energy where it is a very process oriented and its energy is used for melting, cooling, grinding and vacuum activities. There are six primary end uses of electricity: air conditioning, lighting, motors, compressors, heating and cooling. Electricity accounts for 80% of the total energy used in plastic manufacturing facilities, which is the highest in all industrial sectors. Energy accounts for 73% of total production inputs in plastic industry, 59% of which attributed by electricity, and 14% attributed by fuel respectively as shown in Figure 8.[19]

[18] Jordan champer Industry, Energy and Environmental Sustainability Unit (2016)
[19] Jordan champer Industry, Energy and Environmental Sustainability Unit (2016)

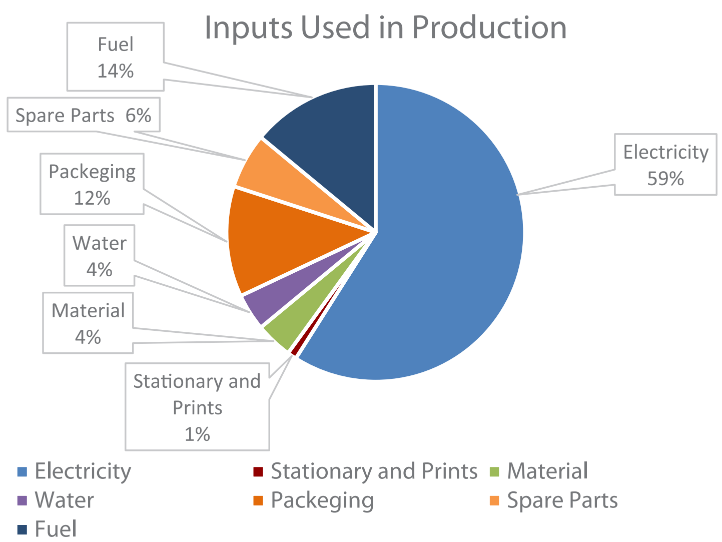

Figure 8: Inputs used in production in plastic and rubber sector

Electric energy is very important to this sector, and any change in the price of electricity will have a direct impact on production costs which in turn leads to a rise in the products selling cost, consequently decreasing its competitiveness in various local and regional markets

2.4.2. Food Industry

The Food, Supplies, Agricultural and Livestock industry sector is one of the most important Jordanian industrial sectors which has a multiplicity and diversity of products offered in local markets. The Food, Supplies, Agricultural and Livestock industry sector includes the following sub-sectors:

- Live animals and animal products and meat.
- Fruits, vegetables and processed products.
- Cocoa and chocolate, sugar, candy, desserts and Eastern sweet products.
- Dairy products.
- Cereals, flour, starch, pastry and bakery products, potato chips and corn.
- Alcoholic and soft drinks, juices, vinegar and mineral water.
- Tobacco and manufactured tobacco substitutes.
- Spices, salt and flavorings.

As it can be noticed from Table 8, the food sector export volume reached 508 million JD in 2014 which contributed to around 2% of total Jordan's GDP.

Table 8: The importance of Food, Supplies, Agricultural and Livestock industry sector [20]

Year 2014	
Capital size	628 million JD
Jordan GDP	25,437 million JD
Export volume	508 million JD
Facilities number	2132
Size of employment	39535

Electricity/Fuel Usage in Food, Supplies, Agricultural and Livestock Sector

Electricity constitutes 13% of the total production inputs cost, and other fuel sources account for 35%, where both combined share less than 50% of the cost of production inputs, as shown in Figure 9. From the energy used perspective, electricity accounted for 29% of the total energy needs of the sector, while the remaining 71% goes for fuel. The sector is considered a medium electricity consumer in general.

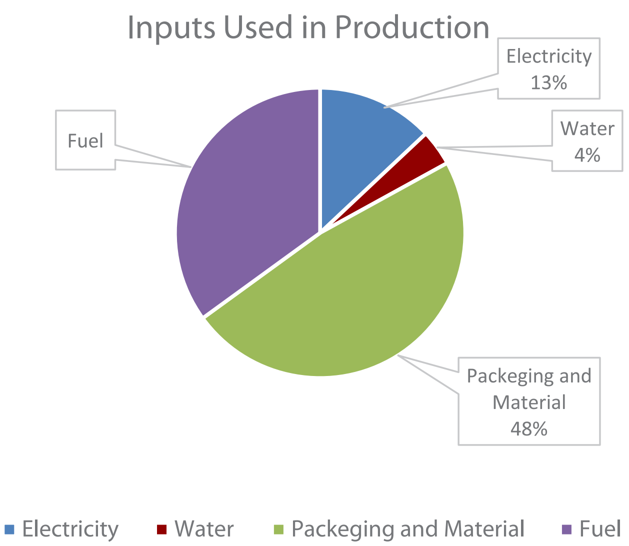

Figure 9: Inputs used in production in food sector [21]

The energy cost differs in several production food sectors. For example; in food and beverage production—especially the bakery industry—the cost of energy is 13.3%, while the energy cost for processing and preserving fruits and vegetables represents (4.92%), production of soft drinks only (4.78%), followed by cocoa, chocolate and sugar confectionery (4.26%) and dairy products (3.96%).[22]

[20] Jordan champer Industry, Energy and Environmental Sustainability Unit (2016)
[21] Jordan champer Industry, Energy and Environmental Sustainability Unit (2016)
[22] Jordan champer Industry, Energy and Environmental Sustainability Unit (2016)

2.4.3. Energy Efficiency and Renewable Energy in Industry

The importance of switching to renewable energy becomes a key decision for all industries. Applications of renewable energy in the industrial sector are different and vary where the most important is the use of photovoltaic technology to convert solar energy into electrical energy, thus reducing the dependence on traditional energy sources. There are many success stories in industrial enterprises that invested in solar energy and reduced their monthly electricity bills by more than 70%.

Solar energy is also used in various industrial sectors such as food factories, plastics, and mechanical bakeries. It is used mainly in heating and evaporation processes, particularly; heating water and air for industrial uses. This is achieved through utilization of solar thermal energy for heating processes instead of using the conventional electric power or other fuel energy sources in heating operations. The usage of solar energy in heating processes has become the most feasible option for several sub-industrial sectors, as a result of dropping cost of solar energy and growing cost of various types of fuel such as diesel and heavy fuel.[23]

There are many applications that will lead to reduced energy costs in industrial facilities, such as the use of solar lighting systems, mainly for outdoor lighting units. These lighting units have selfstorage batteries that save the electricity produced by sun to be used at night when needed.

The empowerment of industrial facilities to benefit from these applications for renewable energy needs huge efforts to increase the awareness and dissemination of the culture of rationalization of consumption.

Improving efficiency in energy use in industrial sector is a key objective of the National Energy Strategy 2007–2020. The second version of NEEAP (2017–2020) has set a target to reduce the energy consumption in the industrial sector by 12.7% by 2020, which will lead to a reduction in demand for electrical energy by 383 GWh annually. The total investment required is estimated to be around 105 million JD and will generate an annual saving of about 53 million JD per year by 2020, with an average payback period of around two years which represents a good profitability.[24]

On the other side, the SwitchMed programme which is funded by the European Union (EU) aimed to support businesses in Jordan to achieve the potential of resource efficiency and cleaner production. The program along with the Royal Scientific Society and Amman Chamber of Industry had conducted energy audits for 12 industrial facilities in the food and beverage sector in Jordan. The results

[23] Eswara and Ramakrishnarao (2013)
[24] National Energy Efficiency Action Plan (2017–2020)

showed a potential of annual energy savings worth 2.1 million euros (1.68 million JD) among a group of 12 participating companies.

Table 9 illustrates the energy saving outcomes in each industrial facility, which varies from a total annual saving of minimum 37,000 euros up to 450,000 euros (29,600 to 360,000 JD) depending on the facility size and other parameters.

Table 9: SwitchMed factories attended [25]

Project	Benefits	nvestment JD	Savings/yr. JD
Yeast Industries Co. Ltd. ASTRICO.	9.6% p.a. Energy savings 10% p.a. Chemical material savings 2.8% p.a. Water savings	88,500	81,275
Al-Durra for General Trading and Investment	1284.4 MWh p.a. Energy savings 631.6 m^3 p.a. Water savings 29t p.a Material savings	64,360	57,000
Al-Haj Mahmoud Habibah & Sons Co.	%27.9 p.a. Energy savings %2.8 p.a. Material savings	50,595	37,720
Bahaa Eldeen Al-Bustanji & Partners Co	%13 p.a. Energy savings %0.7 p.a. Material Savings %34 p.a. Water savings	16,490	28,535
Blue Diamond Food Industries Company	%50 p.a. Energy savings %1 p.a. Material savings	25,370	27,900
Coca-Cola Bottling Company of Jordan	33.5% p.a. Energy savings 2.6% p.a. Material savings 15% p.a. Water savings	79,330	340,000
Farm Dairy Company	%30.5 p.a. Energy savings %0.11 p.a. Material savings %56.5 p.a. Water savings	786,095	170,390
Gulf Food Products Co.	%31.4 p.a. Energy savings %0.07 p.a. Material savings %22.6 p.a. Water savings	36,250	33,300
Jordan Poultry Processing & Marketing Co. PLC	9,354 MWh p.a. Energy savings 14,940 m^3 p.a. Water savings	604,000	363,520
Jordan Valley Food Industrial Co.	%83 p.a. Energy savings %0.2 p.a. Material savings %2.5 p.a. Water savings	32,960	63,155
Saudi Jordanian Industrial Development Company	%22.7 p.a. Energy savings 253m^3 p.a. Water savings	78,370	253,425
Nutridar	%16 p.a. Energy savings %0.1 p.a. Material savings	903,050	153,490

[25] SwitchMed program

The opportunity of saving energy and applying energy efficiency in the food sector is very high as shown in the above Table. 214 resource efficiency measures have been identified during the demonstration project. The majority of the proposed measures covered the following systems:

i. Steam system and heat recovery: In order to reduce fuel consumption; the steam networks have to be examined in order to eliminate heat loss through insulating hot pipes, end users, and condensate tank, and through arresting the steam leakages.

ii. Lighting: by replacing inefficient lighting units with more efficient LED units, proper controlling lighting using motion sensors.

iii. Cooling system: through proper temperature controlling, regular inspection and maintaining the various components of the cooling system

iv. Air leakage and compressed air system: to fix the air leakage and optimize network air pressure in order to reduce the electricity consumption of the compressed air system.

v. Optimization of Cleaning in Place (CIP): The optimization of the CIP will reduce the consumption of water and raw materials mainly through separating the CIP first rinse from other types of wastewater so that it can be reused where appropriate.

vi. Reduction of raw materials losses.

3. Potential Analysis

In this chapter, potential for energy efficiency in Jordan's food and plastics and rubber industries is analysed. First, technical potential will be reviewed on a company level and on a sector level and finally on a national level. Next, a benchmark analysis will show statistical values concerning energy efficiency in Germany. These benchmarks will be compared to Jordanian ones in order to see potential increase of energy efficiency possible in Jordan. Finally, a gap analysis will investigate the differences in the current political and organizational instruments used in Germany to initiate energy efficiency compared to those used in Jordan. This analysis will reveal which instruments will help to successfully initiate energy efficiency in Jordan.

3.1. Technical Potential

Theoretical potential is the maximum possible implementation of a technology, which is under the influence of the interaction between economical supply and demand. Technical potential is the possible realization of the theoretical potential under the consideration of technical, infrastructural and environmental constraints, as well as temporal and spatial discrepancies of supply and demand.[26]

3.1.1. Technical Potential on a company level

There are different tools to assess technical potentials of a company. First, a survey should be carried out to determine basic facts about the company and its energy use. Then, an energy audit can be performed or an energy management system can be implemented. The technical potential of a specific company is depending on the kind of processes that company has implemented and which technical equipment it uses. Thus it must be clarified, that not a statement concerning technical potential for all companies can be given as this is a very individual question. On an individual basis the equipment as well as the processes of a given company can be compared with the best available technology in order to assess saving potentials. Saving potentials can be distinguished in organizational and in technical improvements. Usually organizational improvements, such as avoiding the use of compressed air for cleaning purposes, come with a low investment need and a low or medium complexity of implementation but still can reach high savings. Thus these kind of saving potentials are usually favorited. Technical improvements come with an initial investment need and also with a complexity of implementation. Table 9 describes these initial investment needs, complexity of implementation and the saving potential for different fields of activity. But also here it must be stated that a meaningful register of potentials for a specific company depends on a solid assessment. Nevertheless it can be stated that in the cross-section technology the investment needs and the complexity of

[26] StMWi, 2019

implementation is generally lower than in specific production processes while still yielding high potential savings.

Table 10: Comparison of different fields of activity concerning the saving potential [27]

Field of activity	Investment need	Complexity of implementation	Saving potential
	High / medium / low	High / medium / low	High / medium / low
Compressed air	Low	Medium	High
Ventilation	Low	Medium	High
Air conditioning	Medium	Medium	High
Lighting	Medium	Low	High
Heat generator / heat consumers	High	Medium	High
Refrigeration system	Medium	Medium	Medium
IT Equipment	Medium	Medium	Medium
Production machines	High	Medium	Medium
Specific processes for plastic	High	Medium	Medium
Specific processes for food	High	Medium	Medium

Obviously the field of activity concerning energy efficiency are manifold and each field contains a bundle of potential energy efficiency measures. A list of potential energy efficiency measure can be found in Table 10 in the Appendix 1.

Situation in Germany

In Germany, energy audits are mandatory for companies that are not small- and medium-sized enterprises (SMEs) according to the definition of the European Union (implementation of the Directive 2012/27/EC (Article 8)). The first audit should have taken place before December 5th, 2015. Following the first audit, an audit has to be carried out every four years. The audit has to comply with DIN EN 16247-1. Companies that are already certified after DIN EN ISO 50001 or EMAS (Eco-Management and Audit Scheme by the European Union) are exempt from these obligatory audits.[28] If the company is a SME, tax relief can be granted after conduct of an energy audit. Whether an energy audit is mandatory or not, it is a useful step towards the implementation of an energy management system after ISO 50001 or EMAS. When implementing an energy management system according to ISO 50001, a company continuously improves its energy related performance. Companies of all sizes can either implement an independent energy management system or integrate the energy management in an existing management system such as a quality or environmental energy management system.[29]

[27] Own compilation
[28] BMWi, 2014
[29] TÜV SÜD, 2019

The initiative "energy efficiency networks" by the German government supports voluntary participation in energy efficiency networks, where companies are accompanied by a qualified energy consultant, who moderates the exchange of the companies' experiences, and where they define and realize efficiency goals for the network. Being part of a network is supposed to strengthen the company's awareness of its self-responsibility regarding energy efficiency. For each participating company an energy audit has to be conducted. A savings target according to the companies' goals has to be named for the network. This target is also supposed to raise the savings potentials. The measures implemented are monitored yearly. Energy efficiency networks can have different characteristics, dependant on company sizes and if the network is sector-specific or not.[30]

The acquisition and increase of a company's energy efficiency potential can be achieved by an energy consultation. The consultant analyses the energetic situation of the company, e.g. of the building, processes, plants or mobility, and suggests suitable measures for the increase of energy efficiency.

The acquisition and increase of a company's energy efficiency potential can be achieved by an energy consultation. The consultant analyses the energetic situation of the company, e.g. of the building, processes, plants or mobility, and suggests suitable measures for the increase of energy efficiency. The consultation can lead up to an energy audit according to DIN EN 16247-1. In Germany, energy consultation can be supported by the funding program energy consulting for SME for up to 80%. Another possibility to increase the potential is the implementation of an energy management system. Its aim is to continuously increase energy efficiency by recording energy consumption and cost patterns, improving the energy relevant performance and therefore reducing energy costs sustainably. Depending on energy costs and company size, the implementation of an energy audit or an energy management system can be supported by various funding options, which are discussed in 3.3.2.[31]

On successful way of lowering transaction costs and fostering energy efficiency for companies in Germany was the implementation of energy efficiency networks. By February 2018, 154 Networks have been founded in Germany, including more than 1,500 companies, since 2014. 94% of network participants would recommend the participation to other companies. On average participating companies could save 2.3% energy annually and reduce their average CO_2 emission by 2.4% per year, compared to an "autonomous" energy efficiency progress of about 1% annually.[32]

3.1.2. Technical Potential on a sector level

The technical potential for energy efficiency differs between the various industry sectors. For example, technical potential in the food industry is different from

[30] BMWi, 2014
[31] dena, 2015
[32] Fraunhofer ISI, 2018

technical potential in the rubber and plastics industry, though the cross-section technologies are comparable. Even inside one sector, technical potential varies widely from one type of company to another as the implemented processes and the production equipment differs. As an example for the food industry, technical potential in a bakery will be described in the following section. Then, as another example of the food industry, technical potential for a butcher will be depicted.

In a bakery, 10 to 30% of energy can be saved by using energy efficiently. Most efficient measures can include energy saving in ovens, cooling systems and water heating. Other measures can be time efficient management of the oven, optimal utilization of baking space, precise steaming, continuous baking, energy efficient cooling and freezing, LED lighting in cooling areas, use of waste heat, efficient use of ventilation systems and regular briefing of employees. Energy can also be saved by preventing trash and above average water consumption.[33] Obviously the potentials for cross-section technologies apply for bakeries as well. In addition a list of potentials specifically for bakeries can be found in Table 11

Table 11: Energy efficiency potentials for bakeries

Field of activity	Energy efficiency measure	Saving potential
		High / medium / low
Oven	The oven is switched on as required and loaded on time.	High
Oven	The oven is optimally loaded	High
Oven	The ovens are switched off shortly before the end of the baking time in order to use the residual heat.	Medium
Oven	The steam extraction is adapted to the equipment	High
Oven	The baking program is optimized for the baked goods	High
Oven	The steam device is regularly decalcified.	High
Oven	Oven doors are leak-tight	Medium-High
Oven	Oven doors and external surfaces are adequately insulated	Medium-High
Oven	An exhaust gas flap in the chimney prevents the ovens from cooling down during downtime	Medium
Oven	Separate extractor hoods for steam and exhaust gases were installed.	Medium
Oven	The burners of the ovens are regularly serviced and cleaned.	Low
Oven	The burner is optimally dimensioned and does not run predominantly in partial load operation?	Low
Oven	Has the use of renewable heat sources been verified?	High
Refrigeration of goods	The cooling temperature is adapted to the goods?	Medium

[33] LfU, 2015a

Refrigeration of goods	Is the loss of cold by door openings as low as possible? Employees are informed	High
Refrigeration of goods	Refrigeration rooms are optimally utilized	High
Refrigeration of goods	Refrigerated counters on selling floors are switched off outside business hours	High
Refrigeration of goods	Refrigeration units on selling floors are closed and do not stand next to heat sources.	Medium
Refrigeration of goods	LEDs are used to illuminate the cooling units.	Low
Refrigeration of goods	The doors of refrigeration rooms are leak-tight	High
Refrigeration of goods	Are refrigeration appliances and rooms adequately insulated?	Medium
Refrigeration of goods	Entrances to refrigeration rooms are fitted with cold protection curtains	High
Transport	The route is optimized for the supply of stores	High
Transport	Suppliers are limited to a minimum and deliver as large quantities as possible at the same time.	Medium
Transport	Employees are informed about a usage optimized driving style	Medium

For a butcher, though belonging to the same sector, those energy efficiency potentials are not valid, as the uses processes differ substantially. For butchers using smart energy controlling and load management, cooking more efficiently, using LED lighting in cooling areas, using closed refrigeration units, energy efficient cooling and freezing, intelligent waste heat recovery and briefing employees regularly can foster energy efficiency.[34]

Same holds true for the rubber and plastics industry, only if the type of companies, e.g. injection moulding, is the same similar efficiency potentials can be utilized. Table 11 shows some energy efficiency potentials for plastic industries.

Table 12: Energy efficiency potentials for plastic industries

Field of activity	Energy efficiency measure	Saving potential High / medium / low
Injection moulding	If possible, the injection moulding machines are equipped with electromechanical or hybrid drive systems (hydro mechanical drives require additional cooling for the hydraulics).	High
Injection moulding	Plasticizing cylinders are insulated	High
Injection moulding	Variable capacity pumps are used (rotation speed control via the motor).	High

[34] LfU, 2015b

Injection moulding	Tools and drives are cooled in separate cooling circuits (temperature level of the drive cooling can be significantly higher at approx. 30 degrees).	Medium
Extrusion	The drive is provided by a synchronous motor with gear unit.	Medium
Extrusion	The supply air is heated via waste heat	High
Drying	If possible, drying is carried out by infrared dryers.	Medium
General information	The operating points are energetically optimized	Medium
General information	Continuously heated tools are insulated	Medium
General information	The drive is suitably dimensioned and does not operate permanently in partial load operation.	High
General information	The use of combined heat, power and refrigeration has been verified	High
Oven	The burner is optimally dimensioned and does not run predominantly in partial load operation?	Low

As each type of company in the food or rubber and plastics industry includes different energy relevant processes, different possibilities for using technical potential are given. Therefore, each company has to be examined individually. Performing an energy audit to reveal the performing indicators, as well as the potential and possibilities in saving and efficient use of energy is always very reasonable, no matter what the company's function is.

Nevertheless a sectoral approach to create energy efficiency networks can be favourable, specifically if companies from the same sub-sector are participating. The more similar the processes, the more transferable the improvement measures. But at the same time the competition of potential participants will rise.

3.1.3. Technical Potential on a national level in Germany

Primary energy consumption in Germany was approximately 12,900 PJ in 2018.[35] The final energy consumption, after conversion to secondary energy and the energy production itself, amounted to 9,329 PJ in 2017. From 2008 to 2018, primary energy consumption has been reduced by 10.3% while the final energy consumption between 2008 and 2017 has increased by 1.85%.

Between 2008 and 2017 the primary energy productivity measured in euros per GJ has increased by 17.9% to 215,40 euros/GJ. The final energy productivity has increased by 8.3% between 2008 and 2016 to 310.70 euros/GJ. This indicates that secondary and final energy has been used more efficiently.[36]
This corresponds to Germany's plan for the energy system transformation, which names energy efficiency as one of its central issues.[37] Final energy is consumed

[35] BMWi, 2019
[36] BMWi, 2018

for different purposes, such as cooling or heating of rooms, water and processes, as mechanical energy, for IT and communication, as well as for lighting. With a consumption of 3,520 PJ in 2016 mechanical energy is the most important consumer, followed by heating of rooms with 2,557 PJ and heat for processes with 1,958 PJ. While the consumption of heating of rooms could be decreased by 7.8% between 2008 and 2016 the consumption of mechanical energy rose by 5.3% and the consumption of heat for processes rose by 1.7%. The most drastic increase must be reported for cooling purposes with an increase of 44.9%[38] With a growing economy, it is expected that more final energy will be needed for a wide range of applications in the future. Using the technical potential given by energy efficiency methods and renewable energies is important to keep saving energy while increasing productivity of the German economy. There are many possibilities how the technical potential of using energy efficiency and renewable energies can be implemented. Starting point is the improvement of energy efficiency in cross-sectional technologies. Improvements can concern the production and distribution of compressed air, heating and cooling, electric power units, lighting, the usage of waste heat or organizational measures. The improvement process can be part of joining an energy efficiency network, where 10 to 15 companies work together to share their experiences and to reduce their energy consumption time- and cost-efficiently. As part of an energy efficiency network a company's energy efficiency is enhanced in half the time compared to the rest of the industry. Competitive advantages will be raised as well. About 154 energy efficiency networks exist in Germany. Their success, following the implementation of 10 economic measures per company, is shown in an average energy cost reduction per company of 180,000 euros/year, an average reduction of CO_2 emissions by 2.4%/year, and an average increase in energy efficiency by 2.3%/year in comparison to about 1% average energy efficiency progress annually for the further industry.[39]

3.1.4. Best available techniques

Best available techniques (BAT) describe the state-of-the-art technology, planning, building, maintenance, operation and decommissioning of installations to be used. For each concerned industry, BAT are determined via an information exchange between EU member states, industries and environmental organizations and publicized in reference documents by the European Union.[40] BAT in the food, drink and milk industries for instance are specified by the EU's Integrated Pollution Prevention and Control Directive in the according reference document. Both intermediate products and finished products for consumption are considered, for SMEs as well as for large companies. Production equipment has to comply with all laws and food safety standards. Environmental issues in the food industry are especially water and energy consumption, water contamination and waste minimization. One aim of the BAT is to minimize these environmental issues.[41]

[37] BMWi, 2017
[38] BMWi, 2018
[39] Fraunhofer ISI, 2018
[40] UBA, 2019

Some techniques are relevant across the whole food industry. These best available techniques are widely used, in various processes and for different products. The general BAT include.[42]

- Use of equipment that simplifies operation and maintenance and that optimizes consumption and emission levels
- Use of regular maintenance programs
- Attainment of methods for preventing and minimizing water and energy consumption, as well as the production of waste
- Implementation of a monitoring and reviewing system for consumption and emission levels, at site level and for individual production processes
- Maintaining an inventory of inputs and outputs at all stages of the process
- Minimizing energy usage for heating and cooling processes
- Optimization of the application and use of process controls
- Implementation of an environmental management system

More details on BAT and additional BAT in individual sectors are available in the reference document for the food, drink and milk industry by the EC-IPPC (2006).

BAT concerning the polymer industry are also specified in a reference document by the EC-IPPC (2006). The BAT mainly concern the production installations for one specific polymer. The most commonly produced polymers are polyolefins, polystyrene, polyvinyl chloride, unsaturated polyester, emulsion polymerized styrene butadiene rubbers, solution polymerized rubbers containing butadiene, polyamides, polyethylene terephthalate fibres and viscose fibres. Polymers can be produced in batch or continuous processes. Companies usually manufacture a wide range of basic polymer products, which subsequently are sold to companies who process these to end-user products. Main environmental issues in the polymer sector are VOC (volatile organic compounds) emissions, waste water polluted by organic compounds, solvents and non-recyclable waste, and the high energy demand.[43]

The following generic BAT are usable for all types of polymer installations. Polymer specific BAT are available in the reference document on polymers by the EC-IPPC (2007). Both BAT should be taken into account when regarding a polymer producing company. The generic BAT in the polymer industry are:

[41] EC-IPPC, 2006
[42] EC-IPPC, 2006
[43] EC-IPPC, 2007

- Implementation and compliance to an environmental management system
- Assessment and measurement of fugitive loss to identify high potentials for fugitive loss
- Establishment and maintenance of an equipment monitoring and maintenance and a leak detection and repair program in combination with the fugitive loss measurement and assessment
- Avoiding peak emissions and reducing consumption by minimizing start-ups and stops
- If possible, using power and steam from cogeneration plants
- Recovery of reaction heat through the generation of low pressure steam in processes or plants where external or internal consumers of the low pressure steam are available

Further practices that improve energy efficiency can include:

- switching off compressed air systems outside working hours
- Maintaining compressed air systems regularly and checking for leaks
- Usage of waste heat
- Regular cleaning and replacing of suctions
- Keeping windows in air-conditioned rooms closed
- Regular cleaning and changing of existing filters
- Providing suitable lighting for cold rooms
- Measuring the power consumption of office equipment in different operating conditions
- Switching printer, copier, etc. off after work
- Usage of central multifunction devices
- Using daylight to reduce artificial lighting
- Cleaning and maintaining lights once a year

- Switching off outdoor lighting during the day
- Switching off production machines after the end of operation
- Using a properly sized boiler
- Reducing the flow temperature in production-free times
- Switching off the heating completely in longer periods without heating demand
- ventilating properly

As described above the BAT reference document for the production of polymers describes at great length the best available and thus most energy efficient technology in all relevant process steps for ten production types of the different polymer industries. Thus in this report only a short glimpse of all potential energy efficiency measures can be given. For example BAT for polyvinyl chloride is.[44]

- to use appropriate storage facilities for the vinyl chloride monomer (VCM) feedstock, designed and maintained to prevent leaks and resulting air, soil and water pollution:
  - To store VCM in refrigerated tanks at atmospheric pressure or
  - To store VCM in pressurised tanks at ambient temperature and
  - To avoid VCM emissions by providing tanks with refrigerated reflux condensers and/or
  - To avoid VCM emissions by providing tanks with connection to the VCM recovery system or to appropriate vent treatment equipment.
- To prevent emissions from connections when unloading VCM by
  - Use of vapour balance lines and/o
  - Evacuation and treatment of VCM from connections prior to decoupling
- To reduce residual VCM emissions from reactors by an appropriate combination of the following techniques:
  - Reducing the frequency of reactor openings
  - Depressurising the reactor by venting to VCM recovery

[44] EC-IPPC, 2007

- o Draining the liquid contents to closed vessels
- o Rinsing and cleaning the reactor with water
- o Draining of this water to the stripping system
- o Steaming and/or flushing the reactor with inert gas to remove residual traces of VCM, with transfer of the gases to VCM recovery.

3.2. Benchmark Analysis

3.2.1. Energy consumption and emissions in Germany

Consumption of primary energy in Germany amounted to 3,739,837 GWh in the year 2016.[45] 26% of the primary energy was used or lost in the energy sector and 7% was consumed non-energetically. About two thirds of the primary energy was used as final energy.

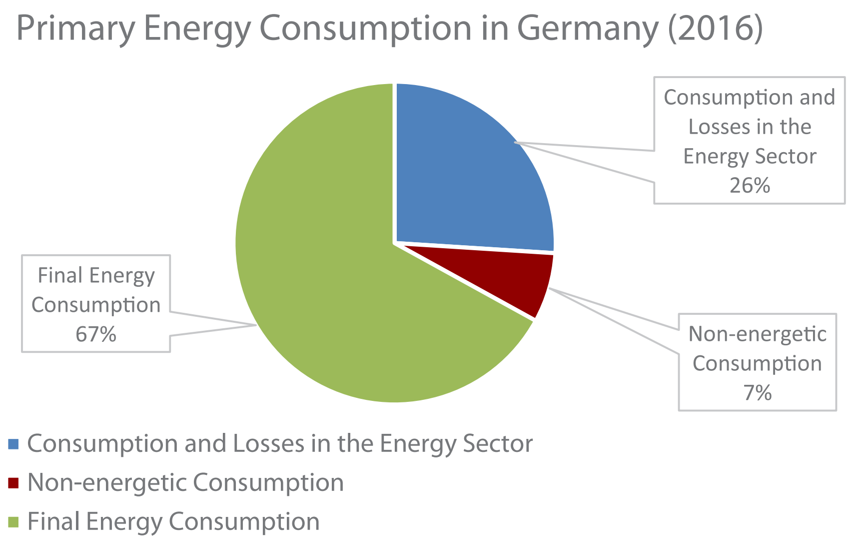

Figure 10: Primary energy consumption in Germany (2016)[46]

Most of the final energy was consumed in the households, business and service sector, which amounts with 1,046,341 GWh to 41%. The transport sector used 30% of the final energy, with a total of 746,341 GWh. Mining and industry consumed 721,138 GWh or 29% of the final energy.[47]

[45] AGEB, 2018
[46] AGEB, 2018
[47] AGEB, 2018

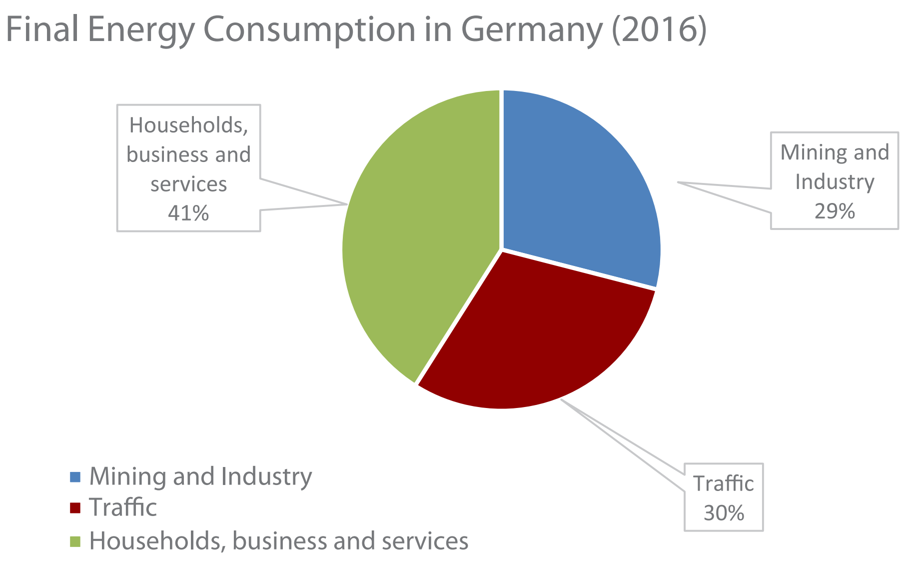

Figure 11: Final energy consumption in Germany (2016)[48]

The largest share in Germany's electricity mix in 2016 was renewable energies with 30%. Brown coal amounted to 22%, black coal to 16%, gas to 14% and nuclear energy to 13%.[49]

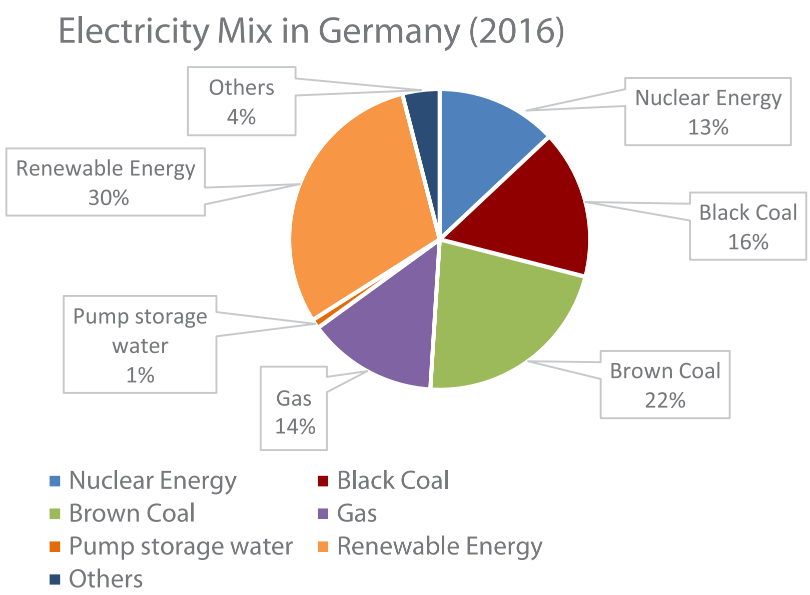

Figure 12: Electricity mix in Germany 2016 [50]

Emitted CO_2 in Germany amounted to 798 million t in 2016. The majority of CO_2 was emitted in the energy sector (41%). The transport sector contributed 21% of the emissions, households, business and services 17% and industry and mining 16%. CO_2 emitting processes added another 5%.[51]

[48] AGEB, 2018
[49] UBA, 2017b
[50] UBA, 2017b
[51] UGRdL, 2018

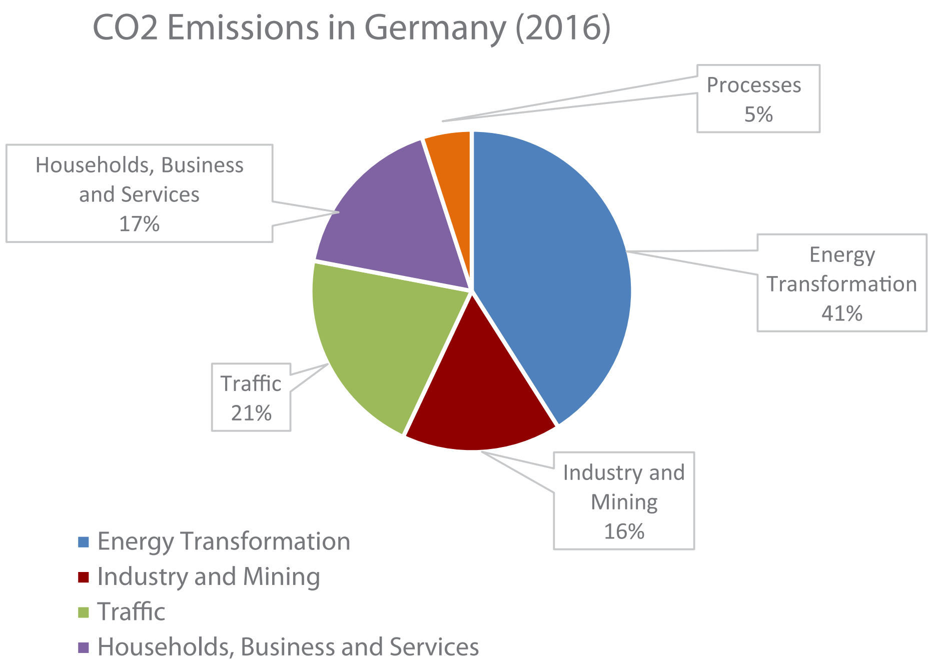

Figure 13: CO2 emissions in Germany 2016 [52]

3.2.2. Renewable energy in Germany

The share of renewable energy in the primary energy consumption has increased over the last decades. In 1990, renewable energy amounted to only 1.3%, whereas it accounted for 4.5% of the primary energy consumption in 2004. Since then, the amount of renewable energy has steadily increased. In 2016, a share of 12.6% was reached.

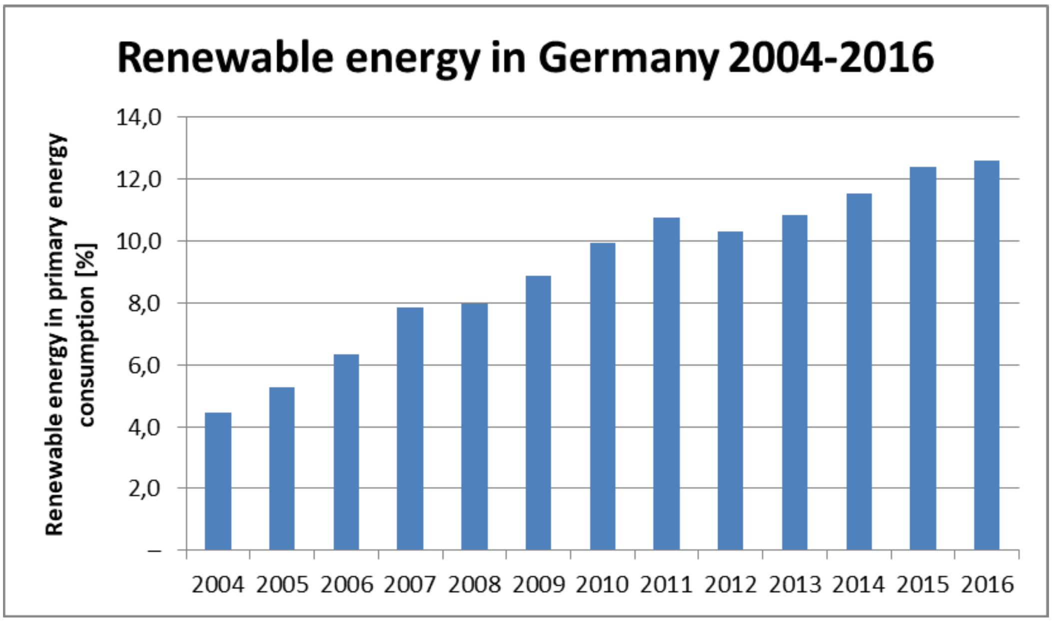

Figure 14: Renewable energy in Germany 2004–2016

[52] UGRdL, 2018

The increase of renewable energy contributed to the reduction of Germany's greenhouse gas emissions. In 1990, emissions amounted to approximately 1.2 billion t CO_2 equivalents. In 2015, emissions were reduced to 903 million t CO_2 equivalents.[53] Further causes for the reduction of greenhouse gases are the implementation of energy efficiency and emission saving strategies.

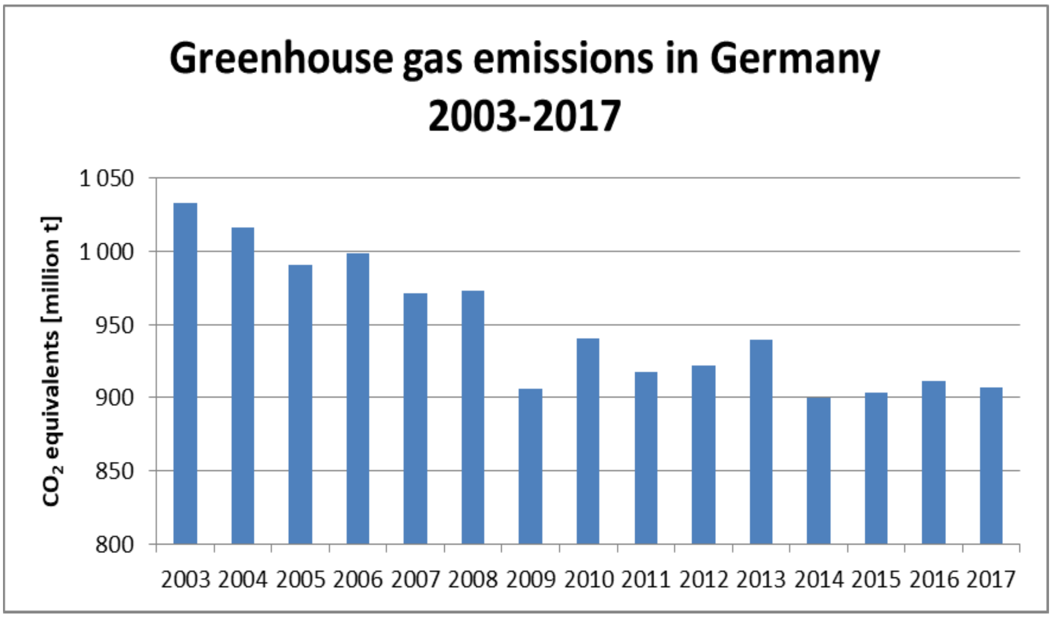

Figure 15: GHG emissions in Germany 2003-2017

3.2.3. Energy consumption in the food industry

The German food industry, including the production of food, beverages and tobacco, consumed 223,424 TJ energy in the year 2015. This amounts to less than 1% of the total energy consumption in Germany.[54] In 2015, 33,904 companies were registered in the food industry. The majority of companies are quite small, with a maximum of nine employees. A total of 760,279 employees generated revenue of 208 billion euros.[55] Regarding the consumption of energy, 81,630 kWh were used per employee and 297 kWh per 1,000 euros revenue. [50, 51]

The energy consumption in the food industry in 2016 mainly consisted of the consumption of gas (52%), with a total of 119,811 TJ. 31% was consumed as electricity, amounting to 71,043 TJ. Mineral oils accounted for 8%, district heat for 5%, brown coal for 2%, and black coal as well as biomass for 1%[50] The total share of renewable energies used (biomass and in electricity) amounts to 10.3%.[50, 56]

[53] UGRdL, 2018
[54] Destatis, 2018
[55] Destatis, 2017
[56] UBA, 2017b

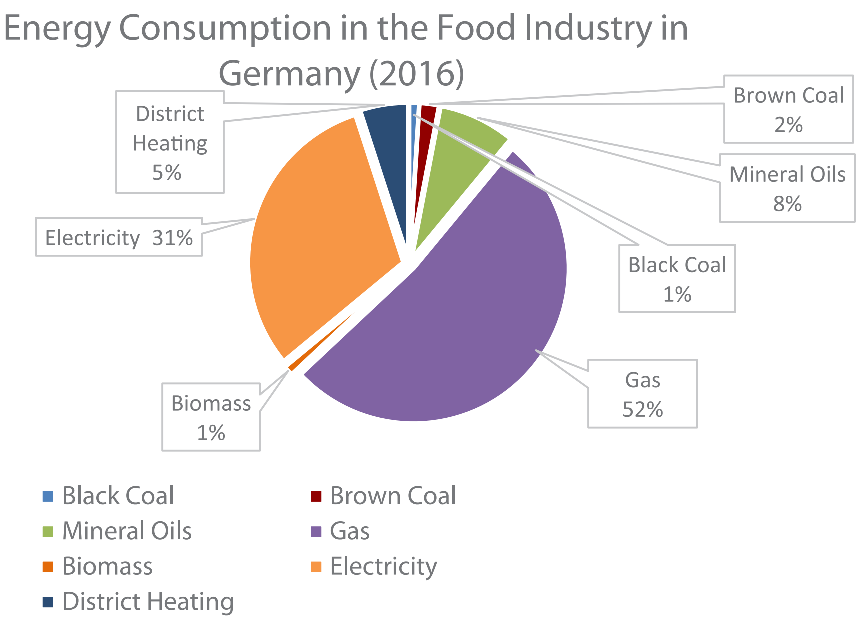

Figure 16: Energy consumption in the food industry in Germany 2016.[57]

3.2.4. Energy consumption in the plastics and rubber industry

The German plastics and rubber sector consumed a total of 94,440 TJ energy in 2015, which also amounts to less than 1% of the total energy consumption.[53] 8,468 companies belonged to the plastics and rubber sector in 2015. About half of the companies are small with less than 10 employees, approximately a quarter of companies employs 10 to 49 persons. There were 1,341 companies with 50 to 249 and 292 companies with more than 250 staff members. Revenue of 84 billion euros was generated by 408,017 employees [58] 64,294 kWh were consumed per employee and 309 kWh per 1,000 euros revenue. [53, 54]

58% of the total energy consumption in the plastics and rubber industry in the year 2016 were consumed as electricity, amounting to 56,129 TJ. 25,292 TJ gas made up 26% of the energy consumption. Mineral oils accounted for 9%, district heat for 5%, and renewable energies in the form of biomass to 2%. The total share of renewable energies from biomass and electricity adds up to 19.4%. [53, 59]

[57] Destatis, 2018
[58] Destatis, 2017
[59] UBA, 2017b

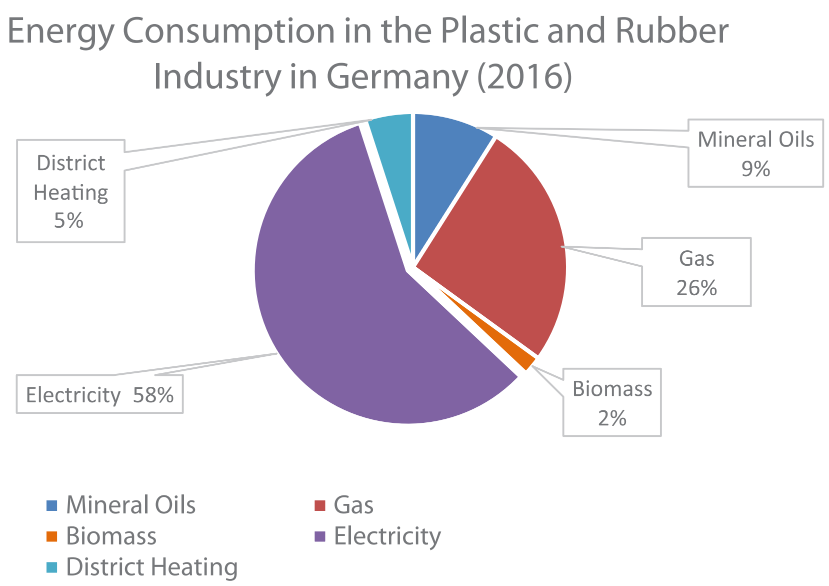

figure 17: Energy consumption in the plastic and rubber industry in Germany 2016 [60]

3.2.5. Comparison of benchmarks

Jordan uses the majority of its total energy for the transport sector (48%), which only amounts to 30% in Germany. The industry sector accounts for 17% in Jordan, for 29% of energy consumption in Germany. The sector with the highest energy consumption in Germany is households, business and service (41%), which amounts to 35% in Jordan.

The German food industry mostly uses energy in the forms of gas (52%) and electricity (31%). Jordan, on the other hand, consumes 29% of its energy as electricity and the remaining 71% as fuel. The electricity share is therefore fairly equal. With 33,904 companies, the German food industry is larger than in Jordan, where 2,132 companies belong to this sector. The food industry makes up 0.98% of companies in Germany. In Germany's food industry, 81,630 kWh were consumed per employee and 287 kWh per 1,000 euros revenue.

The rubber and plastics industry in Germany mostly consumes electricity (58%) and gas (26%). In Jordan, 80% of the energy is provided in the form of electricity. The German industry includes 8,468 companies (0.24% of all companies), the Jordanian one 503. In the plastics and rubber industry, this amounted to 64,294 kWh/employee and 309 kWh/1,000 euros revenue.
As data to calculate key indicators, such as energy consumption per employee or energy consumption per revenue is lacking for the given sectors in Jordan a comparison is not possible. But as stated above within the sectors itself there is a great heterogeneity. Thus, if one strives for energy efficiency improvement an

[60] Destatis, 2018

overall indicator, pointing out average values, might be misleading. Depending on the production depth of a given enterprise the specific key indicators will vary substantially from the average of the sector. If only benchmark indicators would be used to assess energy efficiency it is likely that the focus group of improvement measures will not be met.

The share of renewable energy has increased in the past decades in Germany, as mentioned before. In the food industry as well as in the rubber and plastics industry renewable energy from biomass is used. In 2016, 2,717 TJ were consumed in this way by the food industry, and 1,524 TJ by the rubber and plastics industry.[56] In Jordan, renewable energy is mostly provided by photovoltaic installations, and also by solar thermal energy or in the form of solar lighting.

3.3. Gap Analysis

3.3.1. Political and organizational measures in Germany

In Germany, energy efficiency is initiated and implemented by a wide range of political and organizational measures. The government specified those in the national action plan for energy efficiency (Nationaler Aktionsplan Energieeffizienz (NAPE)) in 2014. The main goals of NAPE are to promote energy efficiency in the building sector, to establish energy efficiency as a business and rate of return model, and to increase self-responsibility regarding energy efficiency[61]. Measures can either concentrate on the information on energy efficiency, offer financial incentives, be a part of regulatory law, or be a combination of two of the stated measures. For the industry and business and service sectors, compliance with the energy saving law (Energieeinsparverordnung, EnEV) and performing energy audits in non-SME companies is obligatory. However, most measures in these sectors include informing of and consulting on energy efficiency.[57]

Germany's energy politics are based on the defined goals of a reduction of the primary energy consumption by 20% until 2020 and by 50% until 2050, compared to the year 2008. This fits in with the EU's goal to reduce primary energy consumption by at least 27% until 2030.[57] It is also Germany's aim to reduce electricity consumption by 10% until 2020 and by 25% until 2050. [62] The measures of NAPE are meant to reduce the consumption of final energy, by increasing energy efficiency, and therefore also reduce the consumption of primary energy. Since enhancing energy efficiency, Germany has decoupled its energy use from its economic growth, which only a few industrial countries have been able to. As mentioned before, information and consulting are the main focus of measures of energy efficiency. Examples are the energy consulting for SME (Energieberatung Mittelstand) or the initiative energy transformation and climate protection for SME (Mittelstandsinitiative Energiewende und Klimaschutz).

[61] BMWi, 2014
[62] UBA, 2018

Funding programs include the building renovation program regarding CO_2 (CO_2-Gebäudesanierungsprogramm) or the energy efficiency program by the KfW development bank for SME companies, which enables those companies to get low-interest loans for energy efficiency measures. Support can also be granted for the implementation of highly efficient cross-sectional technology, energy efficient production processes and energy management systems. The energy saving regulation (EnEV) states minimum requirements for energetic quality of buildings and plant engineering. Regulatory laws also concern the energy labels of products or immitting installations (BImSchG).[63]

The EU's policy on energy efficiency demands energy audits for large companies (non-SMEs) and the reduction of energy sales by 1.5% per year for every energy provider.

Within the German electricity and energy taxes, for specific companies, peak balancing is possible. For non-SME that want to qualify for this tax reduction ISO 50001 or EMAS is mandatory, SME that want to benefit can also perform an energy audit according to DIN 16247. Peak balancing is also regulated by § 10 of the electricity tax law (Stromsteuergesetz) and §55 of the energy tax law (Energiesteuergesetz). The electricity tax law (Stromsteuergesetz) and the energy tax law (Energiesteuergesetz) also requests the reduction of energy intensity by 1.35% per year for the whole German industry. The renewable energies law (Erneuerbare-Energien-Gesetz) includes a levy that amounts to 6.4 ct/kWh. Energy intensive companies which use more than 1 GWh only have to pay up to 15% of the levy under certain conditions. One of the requirements is the implementation of EMAS or ISO 50001 into the company.

Those examples state clearly that energy efficiency is not only promoted via initiatives by the German government it is also part of legislation, which enforcement is strengthened step by step.

To promote self-responsibility for energy efficiency the following measures were established. The initiative energy efficiency networks (Initiative Energieeffizienznetzwerke), which is described in 3.1.1, was introduced in 2015 59. In 2015, the first year of the initiative, 29 networks and in 2016 102 networks were formed. The average goal for primary energy saving is 40 GWh per network. The government's goal to save 75 PJ until 2020 is achievable, if a total of 500 networks each realize energy savings worth 40 GWh.[64]. Therefore, the aim is to initiate 500 such networks by 2020. The mandatory energy audit for non-SME companies was introduced to increase self-responsibility as well 59. That way, approximately 50,000 non-SME companies were obliged to conduct an energy audit.[65] The initiatives for energy transformation and climate protection, as well as the energy consulting for SME are to be further developed [59].

[63] BMWi, 2014
[64] BMU, 2018
[65] IREES, Adelphi, 2017

Successful climate protection not only includes energy efficiency, but also renewable energies [59]. The use of renewable energies is supported in Germany as well. Since this study report concentrates on energy efficiency, renewable energies in Germany will not be further discussed.

3.3.2. Support and funding of energy efficiency in Germany

The implementation of energy management systems and the conduction of energy audits are of course connected to costs. For example for an ISO 50001 certification, an auditor as well as a consultant is needed for several days. Daily rates amount up to 1,250 euros. Running costs for further audits and actions need to be added on top. Another thing to consider is that the company itself needs to delegate the implementation of the energy management system to one or more employees for several months.[66] The audit report is transferred on average 4.4 months after the commissioning of the energy audit. The auditor is usually on site for 6.7 days. The larger the company, the more time is spent on the audit report and by the auditor. The certification of a management system takes on average 7.1 days. The implementation of a management system is more expensive than an energy audit, especially concerning the internal personnel costs. The cost for an external auditor performing an energy audit amounts to 13,620 euros, the internal personnel cost to 9,985 euros on average. Costs for a management system include 16,951 euros for external consulting, 9,342 euros for certification, 43,728 euros for staff until the first certification and 30,490 euros for staff after the first certification. Companies with a multi-site-audit can expect even higher cost.[67] Funding for an energy audit can be granted in the scope of the energy consulting for SME program. Approximately half of the costs can be covered by the support program. Consulting is in general slightly more expensive for consulting. [62]

The German government has been funding the action program climate protection 2020 (Aktionsprogramm Klimaschutz 2020) with 150 million euros yearly since 2016. More than 12 billion euros are available for the measures stated in the latter as well as the NAPE until 2020. About 1.2 billion euros fund research in the energy relevant departments. Between 2016 and 2020 a total of 17 billion euros are available to the Federal Ministry for Economic Affairs and Energy (BMWi), of which 2.5 billion euros are dedicated to the implementation of NAPE measures.[68]

The supporting activities concerning energy efficiency of the German government does not focus on one specific sector but focuses on SMEs. In addition to that many industry associations and chambers have special energy efficiency programs for their partner companies.

[66] UBA, 2018
[67] IREES, adelphi, 2017
[68] BMU, 2018

3.3.3. Development of energy efficiency in Germany

About 11,000 to 22,000 companies of Germany's industry sector and about 33,000 to 51,000 companies in the business and service sector have conducted an energy audit so far. Between 6,000 and 8,000 companies in the industry sector and 4,000 to 13,000 companies in the business and service sector have implemented an energy management system. The larger the companies, the larger is the share of companies with an energy audit and an energy management system. Additionally a total of about 1,200 EMAS organizations are registered in Germany and about 10,000 certificates according to ISO 14001 were issued in 2017.[69]

The amount of realized energy efficiency measures is higher in companies which have had an energy audit than in companies without an energy audit (between 10 to 29% more implemented measures depending on the field of technology). The same goes for companies with an implemented energy management system. It can be concluded that energy audits and energy management systems are connected to a realization of an above average amount of energy efficiency measures.[70]

In 2012 and 2013, 7,300 companies were consulted, in the scope of the energy consulting for SME, which was support by a subsidy amount of 13.3 million euros. Following the consultation, companies invested approximately 224 million euros into energy efficiency measures. 49 million euros of energy costs were saved yearly. On average every supported energy consultation led to an energy cost reduction of 6,700 euros/a.[71] From 2008 to 2013 a total of 24,300 funded consultations were carried out. That way, 1.5 TWh energy and 0.6 to 1 million t of CO_2-emissions could be saved yearly. The program led to 0.7 billion euros being invested in efficiency techniques. Including funding, consultations worth 73 million euros were conducted. The consultation also led to on average 1.7 measures regarding efficiency, which would have not been implemented without the consultation. Additionally to saving energy, costs are reduced and it can therefore be concluded that the economy is influenced in a positive way [66].

From 1990 to 2015 productivity of final energy increased by 50% in Germany. In this time frame, the GDP increased by 40%, while the consumption of final energy was reduced by 6%. The de-coupling of GDP from energy consumption can either be caused by an increase in energy efficiency or the change to less energy intensive economic activities. Between 2008 and 2015 the yearly increase of energy productivity amounted to 1.3%. The German government intends a yearly increase of 2.1%, which has not been reached so far. To realize this aim, the NAPE was created. Between 2000 and 2016, the share of renewable energies regarding electricity consumption has risen from 6.2% to 31.7%. The share concerning the final energy consumption has also increased from 3.7% to 14.8%

[69] ISO, 2017
[70] UBA, 2018
[71] IREES, Fraunhofer ISI, 2014

in 2015. The government intends to increase the share of renewable energies in electricity consumption to 35% by 2020[72], this objective could be exceeded 2018 with a share of 37,8%, but it must be stated, that the weather conditions were very supportive that year.[73]

3.3.4. Energy efficiency in Jordan compared to Germany

In Jordan, increasing energy efficiency is a central issue of the National Energy Strategy 2007-2020. The aim is to raise energy efficiency by 20% until 2020. The Jordan Law No. 13 and the Jordanian Renewable Energy and Energy Efficiency Fund were created in 2012 to aid this cause. To reach the energy efficiency goals, the National Energy Efficiency Action Plan was brought to life. The current version plans on reducing the energy consumption by 17.6% until 2020 by implementing a total of 35 key measures.

Germany and Jordan introduced the measures relevant to the improvement of energy efficiency in national action plans. Both countries aim to increase energy efficiency until 2020. Germany plans to reduce (primary) energy consumption by 20%, Jordan by 17.6% until 2020.

As discussed in the previous chapters the background and the situation in Jordan is different to the one in Germany, even though general political goals concerning energy efficiency are rather similar.

In Germany, a very wide range of measures regarding energy efficiency exists and there are several possibilities for funding measures such as consulting, improvement to highly efficient installations or energy efficient building. The multiple ways of supporting energy efficiency across various sectors have been proven to be successful. To initiate energy efficiency effectively in Jordan, some political and organizational measures from Germany could be adjusted for the Jordanian economic sectors.

On the one hand side the legal obligation to perform an energy audit for specific companies (non SMEs) has led to a great amount of conducted energy audits in Germany. Due to that many companies have to deal with energy efficiency of their processes and their equipment. This is the starting point in implementing improvement measures, integrating a legal obligation to perform an energy audit into Jordanian law, could be one way to foster energy efficiency on a national level.

On the other hand tax benefits for companies, which implement energy management systems or energy audits, could be another possibility to convince companies to invest in energy efficiency. This could be limited to certain types of

[72] UBA, 2017a
[73] UBA, 2019

companies, which from a national perspective are more focused on to implement measures, e.g. industries but not trade.

Subsidising the use of the best available technology is another possibility, which could be implemented in Jordan, but therefore a solid base of knowledge on company basis must be available.

In general it can be stated, that, in order to foster energy efficiency on a company level, awareness must be raised. One way to raise awareness in Germany was the introduction of energy efficiency networks, which has proved very successful. As an energy efficiency network can be cross-sectorial as well as sectorial and basically any company can participate, even if a solid background is desirable, the possibility to implement energy efficiency networks in Jordan is given. But to initiate energy efficiency networks a substantial political support must be given.

4. Conclusions

The food industries as well as the plastics and rubber industries in Jordan and Germany not only differ in their structure and size, but also in energy consumption patterns and degree of energy efficiency. A direct comparison between those industries is not possible due to the lack of data. At the moment it is not possible in Jordan to calculate the respective key indicators, e.g. energy consumption per employee or revenue. The sectors themselves are also very heterogeneous. In the food industry, for example, technical potential and best available techniques differ widely between different companies of the same sector, e.g. a bakery and a butcher. Since each company's technical potential is individual, conducting an energy audit is very reasonable. The energy audit reveals possibilities for saving energy and for using energy efficiently. Positive experiences with energy audits have not only been experienced in Germany, but in Jordan as well. The implementation of energy audits or energy management systems have proven to increase the amount of realized energy efficiency measures significantly.

Technically speaking in the beginning of an energy efficiency program the focus should lie on the cross-sectoral technologies, as the initial investment is usually lower compared to the expected savings then in process specific technologies. Also, it can be stated that energy efficiency networks, which have proven to be very successful in Germany, can be a helpful tool to initiate energy efficiency. To initiate energy efficiency in Jordan, energy efficiency programs like the German national plan for energy efficiency could be established in a Jordanian version. The National Energy Efficiency Action Plan, which was already created in Jordan, could be expanded by introducing a broader variety of measures. But the report also summarizes, that the advances in energy efficiency in Germany do not only derive from own initiative of the industry but also by legislative regulations that foster energy auditing and energy management systems. Therefore this report suggests, in order to successfully strengthening energy efficiency in Jordan, tools like energy efficiency networks, energy audits and further organizational and political measures should be introduced and pursued further.

References

AG Energiebilanzen e.V. (AGEB). 2018. Auswertungstabellen zur Energiebilanz Deutschland. 1990 bis 2017.

Al-Rub et al. (2016) Al-Rub, F. A., Damra, Q., & Khasawneh, Q. (2016). Description of Industrial Energy Consumption in Jordan.

Arbeitskreis Umweltökonomische Gesamtrechnungen der Länder (UGRdL). 2018. Umweltökonomische Gesamtrechnungen der Länder. Band 1. Indikatoren und Kennzahlen. Tabellen. Düsseldorf.

Bayerisches Landesamt für Umwelt (LfU). 2015a. Online-Branchenleitfäden – Umwelttipps für Ihren Betrieb. Bäckerei. Augsburg.

Bayerisches Landesamt für Umwelt (LfU). 2015b. Online-Branchenleitfäden – Umwelttipps für Ihren Betrieb. Fleischerei. Augsburg.

Bayerisches Staatsministerium für Wirtschaft, Landesantwicklung und Energie (StMW)i. 2019. Energie-Atlas Bayern. Lexikon. Potenzial. München. https://www.energieatlas.bayern.de/energieatlas/lexikon/p/potenzial.html?pdf=1 (21.05.2019).

Bundesministerium für Umwelt, Naturschutz und nukleare Sicherheit (BMU). 2018. Klimaschutzbericht 2017. Zum Aktionspro-gramm Klimaschutz 2020 der Bundesregierung. Berlin.

Bundesministerium für Wirtschaft und Energie (BMWi). 2014. Mehr aus Energie Machen. Nationaler Aktionsplan Energieeffizi-enz. Berlin.

Bundesministrium für Wirtschaft und Energie (BMWi). 2018. Energieeffizienz in Zahlen. Entwicklungen und Trends in Deutsch-land 2018. Berlin.

Bundesministerium für Wirtschaft und Energie (BMWi). 2019. Zahlen und Fakten Energiedaten Berlin. (letzte Aktualisierung 22.01.2019)

Deutsche Energie-Agentur GmbH (dena). Energiesysteme und Energiedienstleistungen. Energieeffizienz in kleinen und mittleren Unternehmen. Energiekosten senken. Wettbewerbsvorteile sichern. 2015. Berlin.

Eswara and Ramakrishnarao (2013) Eswara, A. R., & Ramakrishnarao, M. (2013). Solar energy in food processing—a critical appraisal. Journal of food science and technology, 50(2), 209-227.

European Commission (EC) – Integrated Pollution Prevention and Control (IPPC). 2006. Reference Document on Best Available Techniques in the Food, Drink and Milk Instudries.

European Commission (EC) – Integrated Pollution Prevention and Control (IPPC). 2007. Reference Document on Best Available Techniques in the Production of Polymers.

Fraunhofer-Institut für System- und Innovationsforschung ISI (Fraunhofer ISI). 2019. Energieeffizienznetzwerke. Karlsruhe. https://www.energie-effizienz-netzwerke.de/een-de/impressum/index.php (27.05.2019).

Fraunhofer Institute for Systems and Innovation Research ISI (Fraunhofer ISI), 2018. Energy efficiency networks: Lessons learned from Germany; European Council for an Energy-Efficient Economy -ECEEE-, Paris: eceee Industrial Summer Study 2018 p.95-104

iea (2018) World Energy Outlook 2018, Retrieved from https://www.iea.org/ newsroom/news/2018/november/world-energy-outlook-2018-examines-future-patterns-of-global-energy-system-at-a-t.html

Industry- Jordan Investment Commission (2018) [10] Industry- Jordan Investment Commission, 2018 https://www.jic.gov.jo/wp-content/uploads/2018/07/Sector-Profile-Industry-Final-Mar-2018-JIC-1.pdf

Institut für Ressourceneffizienz und Energiestragetien GmbH (IREES), Fraunhofer-Institut für System- und Innova-tionsforschung ISI (Fraunhofer ISI). 2014. Evaluation des Förderprogramms "Energieberatung im Mittelstand". Schlussbericht. Karlsruhe.

Institut für Ressourceneffizienz und Energiestrategien (IREES), adelphi consult GmbH. 2017. Analyse der Entwicklung des Marktes und Zielerreichungskontrolle für gesetzlich verpflichtende Energieaudits. Schlussbericht an das Bundesamt für Wirtschaft und Ausfuhrkontrolle (BAFA). Karlsruhe.

International Organization for Standardization (ISO). 2017. The ISO Survey of Management System Standard Certifications (1999 to 2017). ISO 14001. In: https://isotc.iso.org/livelink/livelink?func=ll&objId=18808772&objAction=browse&viewType=1. 25.07.2018

JEPCO (2019), electricity tariff instructions

http://www.emrc.gov.jo/images/electric/retail_elect_tariff_2018_en.pdf

JMEMR Report (2012) JMEMR Report, "Survey of energy consumption in the industrial Sector". Amman, Jordan: Jordanian Ministry of Energy and Mineral Resources, 2012.

Jordan champer Industry, Energy and Environmental Sustainability Unit (2016) [11] Jordan champer industry, Energy and Environmental Sustainability Unit, Analytical studyThe impact of electricity prices on the industrial subsector in Jordan 2016.

MEMR (2019) Ministry of Energy and Mineral Resources, Energy 2019 Facts & Figures: https://www.memr.gov.jo/EchoBusV3.0/SystemAssets/PDFs/EN/BroshorEn2019.pdf

MEMR (2015) Ministry of Energy and Mineral Resources (MEMR) "Annual report 2015". Amman, Jordan, 2015.

MEMR (2016) Ministry of Energy and Mineral Resources (MEMR), Energy 2016 – Facts and Figures, 2016.

MEMR(2017) Ministry of Energy and Mineral Resources (MEMR) "Annual report 2017.

MEMR (2018) Ministry of Energy and Mineral Resources Energy 2018 - Facts & Figures.

National Electric Power Company (2017) annual report 2017, National Electric Power Company. Retrieved from http://www.nepco.com.jo/en/annual_report_en.aspx.

National Energy Efficiency Action Plan (2017-2020) 2017-2020 National Energy Efficiency Action Plan

Statistisches Bundesamt (Destatis). 2017. Statistisches Unternehmensregister. Wiesbaden.

Statistisches Bundesamt (Destatis). 2018. Tabellen zu den Umweltökonomischen Gesamtrechnungen. Teil 2: Energie. Berichtszeitraum 2000-2016.

SwitchMed program.

TÜV SÜD AG. 2019. ISO 50001. Energiemanagementsystem. Munich.

Umweltbundesamt (UBA). 2017a. Indikatorenbericht. Daten zur Umwelt 2017. Dessau-Rosslau.

Umweltbundesamt (UBA). 2017b. Strommix in Deutschland. Dessau-Rosslau. https://www.umweltbundesamt.de/bild/strommix-in-deutschland (28.05.2019).

Umweltbundesamt (UBA). 2018. Branchen- und unternehmensgrößenbezogene Ermittlung von Klimaschutzpotenzialen (Schwerpunkt KMU) durch verstärkte Umsetzung von Energiemanagementmassnahmen in der Wirtschaft. Abschlussbericht. In: Climate Change 21/2018. Dessau-Rosslau.

Umweltbundesamt (UBA). 2019. Beste verfügbare Techniken. Dessau-Rosslau. https://www.umweltbundesamt.de/themen/wirtschaft-konsum/beste-verfuegbare-techniken (27.05.2019).

Umweltbundesamt (UBA). 2019. Erneuerbare Energien in Deutschland 2018. Dessau

Study on energy efficiency potentials in the Industrial Sector in Jordan

Appendix 1 : List of potential energy efficiency measure

Table 13: List of potential energy efficiency measure[74]

Field of activity	Energy efficiency measure	Saving potential High / medium / low
Compressed air	Switch off compressed air systems outside working hours. Possibly with the help of a weekly timer.	High
Compressed air	Unnecessary areas / Compressed air lines should be disconnected from the total net by a stopcock.	High
Compressed air	The compressed air system should be regularly maintained and checked for leaks.	High
Compressed air	The pressure in the network should be adapted to the requirements (if necessary lower the pressure level in small steps).	High
Compressed air	At different pressures required, the reduction of the pressure level in connection with the use of a pres-sure booster should be checked. Alternatively, a decentralized compressed air supply can be checked.	High

[74] Own compilation

Field of activity	Energy efficiency measure	Saving potential High / medium / low
Compressed air	The pressure difference between generator and terminal should be checked; if> 0.5 bar leakages and losses in the pipeline network are to be checked.	High
Compressed air	A higher-level control of several compressed air compressors and / or a frequency-controlled compres-sor should be in use.	High
Compressed air	The location of the compressor should be cool and dry. If not check if a better location is eligible.	Medium
Compressed air	The waste heat should, if possible, be used	High
Compressed air	The switching frequency of the compressor should be checked	Medium
Compressed air	Suctions should be cleaned and replaced regularly.	Medium
Compressed air	The intake air should be as cool as possible.	Low
Compressed air	The compressed air should only be dehumidified as far as necessary	Low
Compressed air	The use of compressed air for cooling or cleaning purposes should be avoided. If necessary, an alterna-tive system should be tested.	High
Compressed air	The compressor should have a high efficiency / A new purchase should have the highest possible effi-ciency.	Medium
Compressed air	The compressed air treatment (reduction of dust, moisture, air, oil) should reflect the needs.	Medium

[74] Own compilation

Field of activity	Energy efficiency measure	Saving potential High / medium / low
Ventilation	The rooms without automatic ventilation should be targeted shock-ventilated.	Medium
Ventilation	Windows in air-conditioned rooms should be kept closed	Medium
Ventilation	An unregulated passage through closed doors should be avoided.	Medium
Ventilation	Moving airflows should be minimized as much as possible.	Low
Ventilation	Internal heat and moisture sources in air-conditioned rooms should be avoided.	Medium
Ventilation	Air ducts should be cleaned regularly.	Medium
Ventilation	Existing filters should be cleaned and changed regularly.	Medium
Ventilation	Gate veils should be installed in front of long-opened hall or workshop gates.	Medium
Ventilation	Efficient fans should be used.	High
Ventilation	Fan and drive motor should be optimally designed.	Medium
Ventilation	A demand-dependent volume flow control should be installed if possible.	High
Air conditioning	For supply air cooling, the free night cooling should be implemented.	High

[74] Own compilation

Field of activity	Energy efficiency measure	Saving potential High / medium / low
Air conditioning	System components, condensers, heat exchangers and above all evaporators and condensers should be cleaned regularly	High
Air conditioning	The recooler should aspirate cold air and aggregates should be spatially separated.	Medium
Air conditioning	Wherever possible, variable speed pumps should be used.	Medium
Air conditioning	The lines should be sufficiently isolated.	Medium
Air conditioning	The waste heat from refrigeration systems should be used.	High
Air conditioning	For a better need adjustment, a cold storage should be integrated. If possible, extinguishing water tanks should be used for cold storage.	High
Air conditioning	The cooling capacity should be adapted to the requirements. The operating times should correspond to the default values.	High
Air conditioning	The cold water inlet temperature should be set as high as possible.	Medium
Air conditioning	The switch-on points of the condenser fans should be optimized.	Medium
Air conditioning	Air circulation should be ensured on all heat exchangers, condensers and thermo valves.	Medium
Air conditioning	Additional fans on compressors should only run during operation of the compressor	Medium

[74] Own compilation

Field of activity	Energy efficiency measure	Saving potential High / medium / low
Refrigeration system	Internal and external heat loads should be reduced as much as possible.	High
Refrigeration system	Defective door seals of refrigerated cabinets and rooms should be replaced.	High
Refrigeration system	Manually operated covers and blinds should be used.	High
Refrigeration system	The lighting of the refrigerated cabinets should be switched off outside the sales hours.	Low
Refrigeration system	Whenever possible the amount of defrosting processes should be reduced.	Medium
IT Equipment	Printer, copier, etc. should be switched off after work. (e.g., with switchable power strips)	Medium
IT Equipment	Desktop computers should be replaced by thin clients/ notebooks.	High
IT Equipment	Central multifunction devices should be mainly used.	High
IT Equipment	For new purchases, attention should be paid to energy consumption.	Medium
IT Equipment	The cooling of the data center should be regularly monitored for temperature increase and adjusted.	High
IT Equipment	The servers should be virtualized if possible.	Medium
IT Equipment	Individual computer workplaces should be switched off at night and also disconnected from the power grid.	Medium

[74] Own compilation

Field of activity	Energy efficiency measure	Saving potential High / medium / low
IT Equipment	The volume of stored data should be reduced if possible.	Medium
Lighting	Daylight should be used to reduce artificial lighting. (Skylight, windows, etc.)	High
Lighting	Lights should be cleaned and maintained at least once a year.	Medium
Lighting	The use of dimmers or lamps with tap-changer should take place.	Medium
Lighting	The light intensity should be adapted to the use of the room. (Performing measurements of LUX strength)	Medium
Lighting	In case of different frequency of use of the lighting, a zone circuit should be installed.	Medium
Lighting	The outdoor lighting should be switched off during the day via the timer or twilight switch	High
Lighting	Older lighting systems should be replaced by more efficient ones.	High
Lighting	Wherever possible and useful, a timer or presence detector should be installed.	High
Lighting	The burning time should be reduced if possible. (e.g., through employee motivation / information)	High
Lighting	Electronic ballasts should be used.	High
Production ma-chines	The production machines should be switched off after the end of operation.	High

[74] Own compilation

Field of activity	Energy efficiency measure	Saving potential High / medium / low
Production machines	The production machines should be regularly maintained preventively.	High
Production machines	The pump capacity should be reduced. Old and unregulated pumps should be replaced.	High
Production machines	The compressed air consumers should be checked for leaks regularly.	High
Production machines	The efficiency class of the engines should be known.	Medium
Production machines	Frequency inverters (FU) should be in use.	Medium
Production machines	Efficiency, age, power rating and operating hours of the engines should be known.	Medium
Heat generator / heat consumers	The burner should not start too often (a good value is highly dependent on the existing circumstances.) In principle, 2-3 starts / h are okay).	Medium
Heat generator / heat consumers	The boiler should be properly sized.	Medium
Heat generator / heat consumers	Possible waste heat sources that can be used for heating support or otherwise should be checked.	High
Heat generator / heat consumers	The flow temperature should be controlled by the outside temperature.	Medium

[74] Own compilation

Field of activity	Energy efficiency measure	Saving potential High / medium / low
Heat generator / heat consumers	The heating curve / characteristic should be adjusted if necessary.	Medium
Heat generator / heat consumers	The flow temperature should be reduced as much as possible.	Medium
Heat generator / heat consumers	In all rooms, especially unused, heating / air conditioning should be checked for necessity.	Medium
Heat generator / heat consumers	In production-free times, the flow temperature should be reduced.	High
Heat generator / heat consumers	Pumps (heating, circulation) should be downshifted in longer idle times.	Medium
Heat generator / heat consumers	The use of controlled high-efficiency pumps should be checked.	High
Heat generator / heat consumers	A hydraulic balancing should be done if necessary.	High
Heat generator / heat consumers	The hot water supply should be switched off at night, on weekends and holidays. (e.g. by installing a weekly timer)	High

Field of activity	Energy efficiency measure	Saving potential High / medium / low
Heat generator / heat consumers	Central hot water heating should be used where appropriate. At long distances, decentralized heating is often more useful. Can hot water be completely / partially dispensed with in areas (also flow reduction)? If this allows a different control of the heating, this increases the saving effect.	High
Heat generator / heat consumers	The use of a CHP should be checked.	High

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