Kantor Management Consultants

DIRECTORATE GENERAL FOR NEIGHBOURHOOD AND ENLARGEMENT NEGOTIATIONS – DG NEAR

Short term high quality studies to support activities under the Eastern Partnership

HiQSTEP PROJECT

STUDY ON ENERGY EFFICIENCY IN INDUSTRIAL SECTORS IN GEORGIA AND AZERBAIJAN

Component 3 Report:

Review of the Energy Use of the Industrial Sector in Georgia and Azerbaijan and Implementation of "Walk-through" Energy Audits in Typical Industries

January 2018

Contents

List of Tables

List of Figures

List of abbreviations

EC	European Commission
EE	Energy Efficiency
EnC	Energy Community
EnMS	Energy Management System
EU	European Union
GDP	Gross Domestic Product
M&T	Monitoring and Targeting
NEEAP	National Energy Efficiency Action Plan
SME	Small-Medium Enterprise
UNIDO	United Nations Industrial Development Organization
VSD	Variable Speed Drive

Preface

This report reviews the energy use of the industrial sector in Azerbaijan and Georgia and elaborates recommendations and proposals for energy saving opportunities following the implementation of walk-through energy audits in typical industries. The report is part of the study “Energy efficiency in industrial sectors in Georgia and Azerbaijan”. The study has been implemented in the framework of the project ‘Short term high quality studies to support activities under the Eastern Partnership – HiQSTEP, EuropeAid/132574/C/SER/Multi’, carried out by an international consortium under the leadership of Kantor Management Consultants.

The study has been implemented between March 2017 and January 2018 by a team under the leadership of George GEORGOCOSTAS (Study Team Leader) and composed of the International Energy Efficiency Experts Konstantinos GEORGAKOPOULOS, Kyriakos ARGYROUDIS, the International Legal Expert Nick PITSAS and the following national experts: Manana DADIANI (Georgia) and Azer ABDULLAYEV (Azerbaijan).

Overall supervision has been carried out by Przemysław MUSIAŁKOWSKI, Team Leader of the HiQSTEP Project.

The views presented in this report are those of the report authors only and do not represent the official position of the European Commission.

January 2018

Executive summary

1.1 Introduction

This report "**Component 3: Review of the energy use of the industrial sector in Georgia and Azerbaijan and implementation of "walk-through" energy audits in typical industries**" is drafted as part of the deliverables of the study **"Energy efficiency in industrial sectors in Georgia and Azerbaijan",** which is implemented under the project "High quality studies to support activities under the Eastern Partnership" (EuropeAid/132574/C/SER/Multi)" – HiQSTEP.

The overall **aim of the study** is to:

> present EU policies, rules, regulations and tools on energy efficiency (EE) and energy savings, emphasizing on selected industries after consultation with the EC
> review the overall methodology for conducting energy audits in the countries under consideration,
> map and assess existing policies, rules, regulations and tools towards the implementation of EE measures in specific industrial sectors in Azerbaijan and Georgia, and
> develop pre-feasibility studies for the implementation of EE measures in typical industries following the completion of short energy audits.

The study also aims to prepare a preliminary list of energy savings possibilities and an evaluation of such possibilities based on energy, environmental, technical, operational and economic criteria. The study will conclude with elaboration of recommendations on how to further enhance industrial EE in Azerbaijan and Georgia.

The study is comprised of three Components:

> **Component 1** reviewed the industrial EE policies, rules, regulations and tools applicable mostly in the EU and the Energy Community (EnC) Contracting Parties. Component 1 presented also with the methodology, procedures for the conduction of energy audits as well as with the responsibilities of Member States (and EnC Contracting Parties) towards the certification of energy auditors.
> **Component 2** reviewed and assessed the Azerbaijani and Georgian relevant EE framework targeting the industry sector with focus on identifying gaps and elaborating proposals for sustainable EE improvement in industry.
> **The present Component 3** includes a review of the energy use of the industrial sector in both countries and the implementation of five walk-through energy audits for the implementation of EE measures in typical industries following the completion of short energy audits. Component 3 concludes with elaboration of recommendations and proposals for energy saving opportunities in the two beneficiary countries.

In more detail, the **aim of the present report, which relates to Component 3 of the study** is to:

> Present data on energy consumption in the industrial sub-sectors of Georgia and Azerbaijan and identify the most energy consuming sub-sectors

- Conduct five walk-through energy audits in SMEs in both countries and propose targeted EE measures based on the respective findings
- Propose a catalogue of energy saving possibilities of horizontal nature, applicable to the industrial sector of both countries
- Elaborate concrete recommendations / proposals to promote the EE concept, focusing mainly to SMEs.

1.2 Energy consumption in industry

1.2.1 Georgia

The industry sector plays an important role in the development of country's economy. Georgian industry however is not a large energy consumer; the industry consumed 22% (i.e. 10.5 TWh) of total energy consumed in Georgia in 2014. The most energy consuming sectors are:

- **Non-metallic minerals**, representing almost 39% of total energy consumption
- **Iron and steel**, representing almost 37%
- **Food, beverages and tobacco**, representing 8.5%[1], and
- **Construction,** representing 6.6%.

These sub-sectors altogether stand for approximately 90% of the total energy used.

1.2.2 Azerbaijan

The country is almost fully supplied from locally available energy sources emphasizing on hydrocarbons and is a net exporter of oil and natural gas, particularly for the European markets.

The industry is one of the most developed sectors in Azerbaijan. The most energy consuming sector in the country is the household sector (40.5% of the final consumption) followed by the industry and construction (24.9%) and transport (23.6%) sectors. In 2016, the final energy consumption reached 1,563.5 ktoe or 18,184 GWh. The most energy consuming industrial sectors are:

- **Food and tobacco**, representing almost 26% of total energy consumption
- **Chemical and petrochemical**, representing approximately 25.5% of total energy consumption
- **Non-metallic minerals**, representing approximately 22%, and
- **Construction**, with a share of almost 11% in the total energy consumption.

1.3 Energy audits in SMEs in Georgia and Azerbaijan

Considering the type of auditing (walk-through audits) and the time limitation of the audits, the Study Team considered the following criteria for selecting the industries:

- **Replicability**: the EE measures that will be proposed should have replicability or, at least, attract the interest of as many as possible similar enterprises in the country. In this respect, selection of SMEs is the preferable option, since large scale, energy intensive industries are technology-specific and replicability of EE measures is very limited.

[1] According to the NEEAP report, the Food, Beverages and Tobacco sector is considered under-reported in the official energy balance.

- **Effectiveness of the audits**: Given the time limitation for conducting the energy audits, it is more effective to audit an SME rather than a large industry which would require more resources to conclude to useful recommendations.
- **Acceptance and data availability**: It is important that the management of each industrial facility to be audited will recognise its benefit from the audit, accept to avail all necessary data prior to the audit and commit specialised staff to collaborate with the auditors during the audit.

In **Georgia**, since 2014, 18 energy audits have been performed in SMEs in the framework of the UNIDO demonstration component of the EU's program Greening Economies in the Eastern Partnership Countries (EaPGREEN) project "Resource Efficient and Cleaner production (RECP). The Study Team considered this as a good opportunity to sought synergies and capitalize the work conducted. In this respect, the Study Team performed walk-through energy audits in 3 of these SMEs with the aim to **check** / **verify the findings** of the energy audits performed during the previous project and **identify the reasons** / **difficulties of non-implementation**. The industries that were selected belong to the sectors of food & beverage (2 industries) and paper manufacturing (1 industry).

In **Azerbaijan**, a different approach was followed. The Study Team contacted 20 industries, belonging most of them to the SME sector. Due to the low interest and willingness to perform energy audits, only 2 SMEs responded positively. These companies belong to the sectors of manufacturing of wood products and manufacture of plastics.

1.3.1 Energy audit findings

The main findings identified were:

- Lack of financing
- Limited policies and enforcement
- Limited information (in some cases limited knowledge)
- Low level of management awareness on EE
- Obsolete and inefficient equipment

1.4 Energy efficiency measures applicable to industries in Georgia and Azerbaijan

The EE measures proposed for the industrial sectors in Georgia and Azerbaijan refer to cross-cutting / horizontal EE technologies instead of EE technologies in each industrial process, since each industrial sector has specific process lines and the EE measures that can be applied are sector-specific, more complex in nature and require major investments.

The EE measures proposed per technology are presented in the following.

1.4.1 Electricity supply and consumption

Potential energy saving opportunities are:

- Shut-off sections which do not require electricity when in operation
- Shifting loads to the off-peak times
- Load management
- Installation of soft starters in large motors to avoid peaks at start-up times

- Replacement of excessively oversized transformers
- Cogeneration; a precondition is the coincidence of electricity and the relatively high demand for steam.

1.4.2 Steam generation and distribution

Steam and high temperature hot water boilers offer many energy savings opportunities which can make significant cost savings to industries. The most appropriate option depends on the type of boiler and heating system, the requirements of the process or other heating demands and budget. Table 1-1 presents energy saving measures in terms of their effectiveness in reducing energy consumption.

Table 1-1: Energy saving measures in steam generation and distribution

Measure	Energy Savings
Improve combustion efficiency by reducing excess air to minimum ratio, cleaning boiler heat surfaces as soon as flue gas temperature tends to increase[2]	Up to 5% (efficiency increase by about 0.5% for every 1% decrease in O_2)
Boiler and burner management, digital combustion controls and oxygen trim[3]	Up to 5%
Locate and repair steam leaks in fittings, equipment and steam traps[4]	10% - 15%
Insulate pipelines and equipment[5]	3% - 13%
Increase condensate return rate. In case there is no condensate return line at all, consider retrofitting of condensate return line in the whole system or in parts of it where it is financially viable[6]	Up to 10%
Retrofit the boiler with economizer and recover flue gas heat, if flue gas temperature remains high, after cleaning (economizers are usually viable for boilers with a capacity of over 3 MW)[7]	5%, up to 15% for condensing boilers
Install VSDs for fans, blowers and pumps[8]	Up to 50% of energy use are achievable by reducing the fan or pump motor speed by 20%
Boiler and burner management, digital combustion controls and oxygen trim[9]	Up to 5%
Make use of waste heat from production processes to preheat combustion air	Case specific
Boiler replacement if the existing boiler is excessively oversized and outdated	Case specific
Use of alternative fuels such as biomass	Case specific
Improve housekeeping and maintenance	Case specific

1.4.3 Compressed air

Energy saving opportunities in compressed air systems are presented in Table 1-2.

[2] http://www.ecoen.co.in/boiler.html
[3] https://www.carbontrust.com/media/13332/ctv052_steam_and_high_temperature_hot_water_boilers.pdf
[4] Spirax Sarco, Optimising steam system Part I
[5] Spirax Sarco, Optimising steam system Part I
[6] https://energy.gov/sites/prod/files/2014/05/f16/steam8_boiler.pdf
[7] https://www.carbontrust.com/media/31715/ctg057_heat_recovery.pdf
[8] Carbon Trust, Motors and Drivers, CTV048
[9] https://www.carbontrust.com/media/13332/ctv052_steam_and_high_temperature_hot_water_boilers.pdf

Table 1-2: Energy saving measures in compressed air systems

Measure	Energy Savings
Turn off the back-up compressor until it is needed and during non-working time	Case specific
Conduct leakages test periodically and repair leakages[10]	~ 20%
Consider alternatives to compressed air such as hydraulic rather than air cylinders, electric rather than air actuators and electronic rather than pneumatic controls	Case specific
Identify real pressure requirements of users, set user pressure as low as possible and reduce air compressor discharge pressure to the lowest acceptable setting	Reduction of the operating pressure from 7 to 6 bar for example, will result in electricity cost savings of about 6% to 10%
Identify branches of the distribution system with users of lower pressure requirements and consider retrofitting throttle valves	Case specific
Consider installation of a control system to optimize operation of unit station[11]	~ 12-15%
Consider variable speed drive (VSD) for variable load on positive displacement compressors[12]	~ 2%
Consider cooling intake air	4°C lower inlet temperature results in 1% increase in efficiency
Consider heat recovery at very large compressors[13]	~ 20-80%
Keep air treatment to the minimum possible	Case specific
Eliminate bottlenecks causing excessive pressure drop in the distribution system	Case specific

1.4.4 Electric motors

Table 1-3 presents energy saving opportunities in electric motors.

Table 1-3: Energy saving measures in electric motors

Measure	Energy Savings
Make use of gravity instead of pumping wherever possible	Case specific
Operate pumps, fans and blowers near the best efficiency point	Case specific
Consider replacement of impellers or turning-down of the diameter of impellers to reduce throttling and power input	Case specific
Consider use of smaller motors after optimizing devices	Case specific
Consider sequence control of smaller and VSD for large unit whenever there is wide load variation	Case specific
Consider the installation of high efficiency motors for near continuous operation over the year	Case specific

1.4.5 Pumps

Energy saving opportunities in pumping systems are presented in Table 1-4.

[10] Reference document on best available techniques for energy efficiency, February 2009
[11] Reference document on best available techniques for energy efficiency, February 2009
[12] Reference document on best available techniques for energy efficiency, February 2009
[13] Reference document on best available techniques for energy efficiency, February 2009

Table 1-4: Energy saving measures in pumping systems

Measure	Energy Savings
Shut down unnecessary pumps	-
Trim or change impellers if head is larger than necessary[14]	Case specific
Replace oversized pumps with more efficient models[15]	1-2%
Use multiple pumps instead of one large one	Case specific
Change the speed of a pump for the most efficient match of horsepower requirements with output[16]	5-40%

1.4.6 Lighting systems

Table 1-5 presents energy saving opportunities in lighting systems.

Table 1-5: Energy saving measures in lighting systems

Measure	Energy Savings
Use of high efficiency lamps and luminaires[17]	~ 75% from incandescent to LED lamps and ~45% from T12 to T5
Change high-pressure mercury lamps against metal halide lamps	-
Implement automatic time switches and motion detectors	-
Use electronic ballasts[18]	~ 20%
Implement modern lighting management systems[19]	~ 30 - 50%

1.4.7 Industrial refrigeration and cooling

Table 1-6 presents energy saving opportunities in industrial refrigeration and cooling.

Table 1-6: Energy saving measures in industrial refrigeration and cooling

Measure	Energy Savings
Refrigeration load reduction	Case specific
Condenser – heat recovery	Up to 30% of the cooling capacity
Improving system controls	2% to 4% for each degree change in temperature
Reducing refrigeration leakage[20]	Up to 15%
Use of high efficiency compressors – increase the compressor size[21]	~ 10% of energy use by increasing the compressor size by 30%
Use of high efficiency fan motors	-
Good housekeeping of refrigeration plants[22]	Up to 10%

[14] https://www1.eere.energy.gov/manufacturing/tech_assistance/pdfs/trim_replace_impellers7.pdf
[15] Energy Efficiency Best Practice Guide, Pumping Systems, Sustainability Victoria
[16] Energy Efficiency Best Practice Guide, Pumping Systems, Sustainability Victoria
[17] https://energy.gov/energysaver/led-lighting & http://greensavingsco.com/2009/12/changing-from-t12-to-t5/
[18] Taking Action on Climate Change, Long term mitigation scenarios for South Africa, Harald Winkler, 2010
[19] https://www.carbontrust.com/media/13067/ctv049_lighting.pdf
[20] Carbon Trust "Refrigeration systems, Guide to energy saving opportunities, CTG046, 2008"
[21] Carbon Trust "Refrigeration systems, Guide to energy saving opportunities, CTG046, 2008"
[22] https://www.carbontrust.com/resources/guides/energy-efficiency/refrigeration/

1.4.8 Furnaces, kilns and ovens

Table 1-7 presents energy saving opportunities in furnaces, kilns and ovens.

Table 1-7: Energy saving measures in furnaces, kilns and ovens

Measure	Energy Savings
Optimization of combustion air[23]	5-25%
Operating at optimum furnace temperature[24]	5-10%
Optimum capacity utilization	Case specific
Use of high temperature heat recovery systems (recuperators or regenerators)[25]	10-30%
Reduction of losses from furnace surface and openings[26]	2-15%
Selecting the appropriate refractories	Up to 25%

1.4.9 Monitoring and Targeting and Energy Management Systems

The purpose of Monitoring and Targeting (M&T) is to relate energy consumption data to the weather, production performance or other measures by providing a better understanding of how energy is being used. In particular, it will identify if there are signs of avoidable waste or other opportunities to reduce consumption.

M&T is a part of an Energy Management system applied to industrial processes.

An Energy Management System (EnMS) is required to create a foundation for positive change and to provide guidance for managing energy throughout an organization. The most recognised tool that helps organisations put in place an EnMS and use their energy more efficiently is the ISO 50001 standard.

1.5 Recommendations

The proposed recommendations by the Study Team are in line with the proposals developed and presented in Component 2 report. These are the following:

Development of capacity building and training activities on industrial EE

The lack of knowledge and information on the benefits of EE investments was one of the major problems identified from the discussions with the management of the SMEs.

In this respect, the Study Team recommends the implementation of capacity building activities to increase the awareness on the benefits of EE investments.

Such capacity building activities can be in the form of training activities, workshops, discussion platforms, working groups, etc. Topics may include technical as well as financial aspects such as energy auditing procedures, measurement and verification techniques, EE technologies, financial appraisal tools and other as deemed necessary, and will need to be formulated and implemented

[23] US DoE "Office of Industrial Technologies, Roadmap for Process Heating Technology, 2001
[24] US DoE "Office of Industrial Technologies, Roadmap for Process Heating Technology, 2001
[25] Reference document on Best Available Techniques for Energy Efficiency, Feb. 2009
[26] US DoE "Office of Industrial Technologies, Roadmap for Process Heating Technology, 2001

not only by the competent State authorities, but also through the international agencies and donors, IFIs and international partnerships. Specifically, for SMEs, training on the optimisation of industrial system and processes can be proved much beneficial.

Capacity building activities will create a number of highly skilled system optimization experts that can provide the necessary technical assistance for industrial facilities to identify and develop EE improvement projects.

Improvement of the existing legislative framework and introduction of key policy initiatives

The lack of effective policies targeting EE in the industrial sector is noted in both countries; on the one hand, Georgia is a Contracting Party of the EnC and is in the process of implementing the EU energy legislation while Azerbaijan, being an exporter of oil and natural gas, EE is not a priority at the moment.

Therefore, it is proposed for **Georgia** to develop the primary EE legislation so as to achieve the goals set out in the first NEEAP. The first step is the adoption of the Energy Efficiency Law, which will transpose the EE Directive (2012/27/EU).

On the other hand, in **Azerbaijan,** the State authorities should focus on the consolidation of the existing laws that affect EE investments into a single legislative act. This act can serve as legal basis for drafting and adopting any secondary legislation in relation to EE. Other key policy initiatives that can be applied in both countries are:

- adoption and implementation of internationally accepted standards on energy auditing and energy management;
- implementation of Energy Management Systems by large industries based on widely acceptable standards, such as the ISO 50001;
- conducting energy audits by industrial operators;
- establishment of an accreditation and certification body for energy auditors;
- imposition of minimum energy performance standards on industrial operators;
- development of industrial clusters / networks on EE.

Formulation of fiscal and financial EE instruments

All stakeholders who have been interviewed mentioned that the **lack of financial resources** and **access to financing** is the most common barrier for EE investments. In this respect, the Study Team recommends for both countries to support industries with targeted programmes of fiscal and financial nature, such as:

- **subsidies** or **grants** to carry out energy audits;
- the provision of **loans** to cover part of the capital cost of some EE interventions;
- investment **credits** or State-backed **guarantees** for the implementation of EE upgrades;
- **tax refunds, deductions, rebates or profit-tax credits**

Financial support from State authorities and international financial institutions **will also be needed in order to provide technical training and capacity building to various stakeholders' groups** (EE consultants, local financial institutions, industry, etc.), support the research, development, demonstration and deployment of EE technologies, including the realisation of pilot projects, improving information dissemination and raising general awareness on the benefits of EE investments in industry.

Monitoring of the implementation of policies and measures

The Governments of Georgia and Azerbaijan should develop policies, initiatives and programmes with specific time horizons in order to support the implementation of EE measures in industry and especially in SMEs.

However, monitoring of these policies and programmes is an important aspect so as to accurately assess and track the progress on the level of their implementation. The Governments of both countries will play a decisive role in this respect. They should allocate responsibilities to authorized state institutions responsible for the industry sector involving in parallel relevant state institutions, local self-governments, energy efficiency centres, industry associations and other stakeholders.

The Study Team recommends making the monitoring system obligatory in Georgia since Georgia has recently joined the Energy Community Treaty as a Contracting Party and all Energy Community Acquis, including the Energy Efficiency Directive (which contains obligations to monitoring and reporting requirements), must be transposed and implemented. The monitoring system is also proposed to be established in Azerbaijan, even if the country has no obligations yet to adopt the EU EE acquis.

2 Introduction

This report "**Component 3: Review of the energy use of the industrial sector in Georgia and Azerbaijan and implementation of "walk-through" energy audits in typical industries**" is drafted as part of the deliverables of the study **"Energy efficiency in industrial sectors in Georgia and Azerbaijan",** which is implemented under the project "High quality studies to support activities under the Eastern Partnership" (EuropeAid/132574/C/SER/Multi)".

The overall **aim of the study** is to:

- present EU policies, rules, regulations and tools on energy efficiency (EE) and energy savings, emphasizing on selected industries after consultation with the EC;
- review the overall methodology for conducting energy audits in the countries under consideration;
- map and assess existing policies, rules, regulations and tools towards the implementation of EE measures in specific industrial sectors in Azerbaijan and Georgia; and
- develop pre-feasibility studies for the implementation of EE measures in typical industries following the completion of short energy audits.

The study also aims to prepare a preliminary list of energy savings possibilities and an evaluation of such possibilities based on energy, environmental, technical, operational and economic criteria. The study will conclude with elaboration of recommendations on how to further enhance industrial EE in Azerbaijan and Georgia.

The study is comprised of three Components:

- **Component 1** reviewed the industrial EE policies, rules, regulations and tools applicable mostly in the EU and the Energy Community (EnC) Contracting Parties. Component 1 presented also with the methodology, procedures for the conduction of energy audits as well as with the responsibilities of Member States (and EnC Contracting Parties) towards the certification of energy auditors.
- **Component 2** reviewed and assessed the Azerbaijani and Georgian relevant EE framework targeting the industry sector with focus on identifying gaps and elaborating proposals for sustainable EE improvement in industry
- **The present Component 3** includes a review of the energy use of the industrial sector in both countries and the implementation of five walk-through energy audits for the implementation of EE measures in typical industries following the completion of short energy audits. Component 3 concludes with elaboration of recommendations and proposals for energy saving opportunities in the two beneficiary countries.

In more detail, the **aim of the present report, which relates to Component 3 of the study** is to:

- Present data on energy consumption in the industrial sub-sectors of Georgia and Azerbaijan and identify the most energy consuming sub-sectors
- Conduct five walk-through energy audits in SMEs in both countries and propose targeted EE measures based on the respective findings
- Propose a catalogue of energy saving possibilities of horizontal nature, applicable to the industrial sector of both countries
- Elaborate concrete recommendations / proposals to promote the EE concept, focusing mainly to SMEs.

3 Energy consumption in industry

3.1 Georgia

The industry sector plays an important role in the development of country's economy. In the sectoral structure of the Gross Domestic Product (GDP) of Georgia, the industry has the largest share with 17.1%, followed by transport and communication services (10.1%, agriculture, forestry and fishing (9.3%), public administration (9.1%), construction (8.3%), real estate, renting and business activities (6.6%), health and social work (5.8%)[27]. Georgian industry however is not a large energy consumer; the industry consumed 22% (i.e. 10.5 TWh) of total energy consumed in Georgia in 2014.

In 2014, the number of active enterprises amounted to 70,760, out of which 6,170 are medium and 60,640 small-sized enterprises. The share of Small-Medium Enterprises (SMEs) in the total number of active enterprises constitutes 94% (medium – 9% and small – 85%). During the period 2006-2014, the turnover of SMEs increased by 269%, from GEL 2.4 bln up to GEL 9.0 bln and output - by 269.7%, from GEL 1.4 bln up to GEL 5.2 bln respectively. Tbilisi has the largest share of turnover (71.8%) and output (64.6%)[28].

Historically, Georgia was a much larger energy consuming country. In 1990, the industry consumed nearly 3 times more energy than in 2013 – 2014. However, since 1990, there was a large reduction in industry (and other sectors) immediately after the break-up of the Soviet Union.

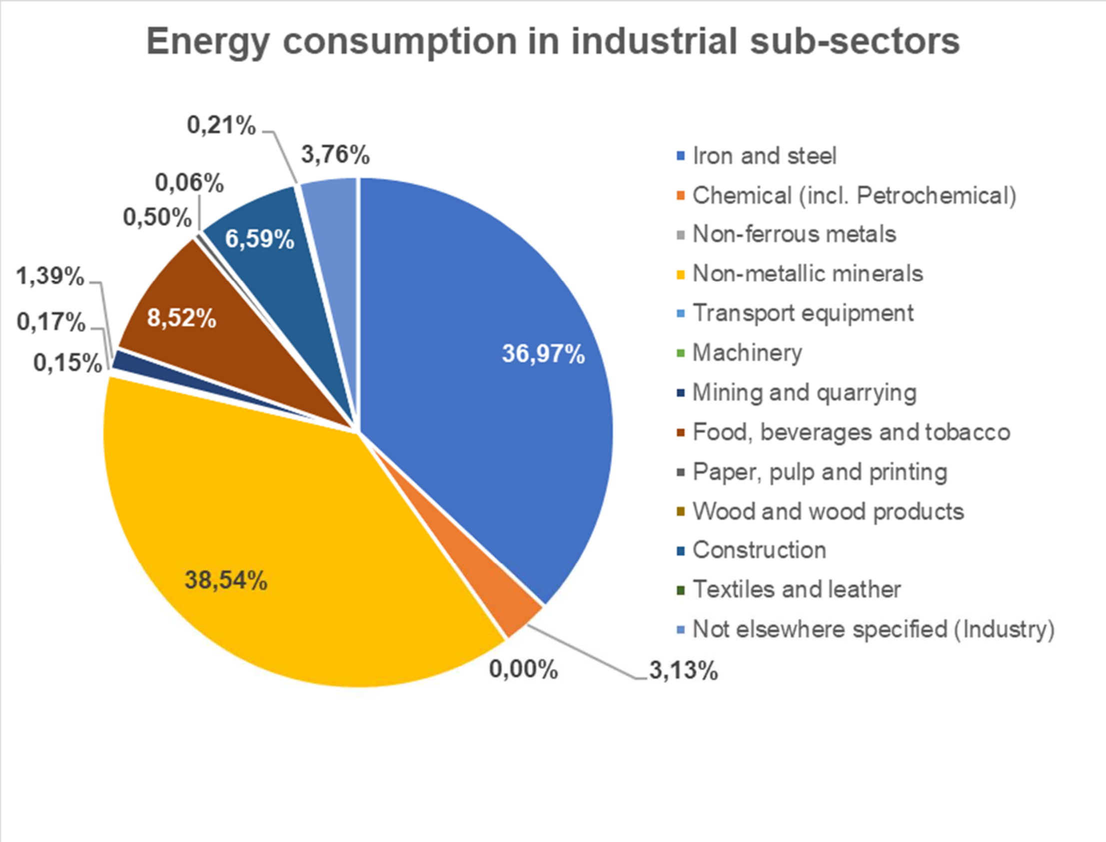
Table 3-1 presents the energy consumption in the main industrial sectors in Georgia and Figure 3-1 depicts the share of its sub-sector in the total energy consumption.

Table 3-1: Energy consumption in the industrial sectors in Georgia (2014)[29]

Industrial sub-sector	Energy consumption (GWh)
Iron and steel	2,634.7
Chemical (incl. Petrochemical)	223
Non-ferrous metals	0
Non-metallic minerals	2,746.4
Transport equipment	10.9
Machinery	12.2
Mining and quarrying	99
Food, beverages and tobacco	606.9
Paper, pulp and printing	35.5
Wood and wood products	4.3
Construction	469.9
Textiles and leather	15.3
Not elsewhere specified (Industry)	267.6
TOTAL	7,125.7

[27] Gross Domestic Product of Georgia 2016 (preliminary results), 21.03.2017, www.geostat.ge
[28] Calculations from GEOSTAT and Ministry of Economics and Sustainable Development
[29] Draft NEEAP report, 2017

Figure 3-1: Share of the energy consumption among the industrial sub-sectors in Georgia



As it can be observed from the above table and figure, the most energy consuming sectors are:

> **Non-metallic minerals**, representing almost 39% of total energy consumption
> **Iron and steel**, representing almost 37%
> **Food, beverages and tobacco**, representing 8.5%[30], and
> **Construction**, representing 6.6%.

These sub-sectors altogether stand for approximately 90% of the total energy used.

Table 3-2 presents estimates of production in the industrial sector. Table 3-3 depicts an effort to present the specific energy consumption in the sub-sectors where data is available.

Table 3-2: Estimates of production in the industrial sector in Georgia[31]

Industrial sub-sector	Approximate production (tons)
Aggregates	12,602,861
Iron and steel	188,737
Chemical (incl. Petrochemical)	45,397[32]
Non-metallic minerals	6,161,029[33]

[30] According to the NEEAP report, the Food, Beverages and Tobacco sector is considered under-reported in the official energy balance.
[31] Draft NEEAP report, 2017
[32] According to the draft NEEAP, this amount is quite low
[33] Approximately 1.6 Mt of cement is produced each year, but there appears to be multiple counting of same product as: clinker, cement then concrete products. Additionally, there may be some multiple counting of aggregates

Industrial sub-sector	Approximate production (tons)
Food & drink	1,518,612[34]
Paper based	21,985
Wood based	59,202
Construction	N/A
Clothing	8,302
Engineering	55,866

Table 3-3: Specific energy use in selected sub-sectors in Georgia

Industrial sub-sector	Specific energy use (kWh/ton)
Iron and steel	13,959.6
Chemical (incl. Petrochemical)	4,912.2
Non-metallic minerals	445.8
Mining and quarrying	7.9
Food and beverages	399.6
Paper, pulp and printing	1614.7
Wood and wood products	72.6

3.2 Azerbaijan

Azerbaijan has experienced rapid economic growth over most of the past decade, largely due to its oil-related reserves. The country is almost fully supplied from locally available energy sources emphasizing on hydrocarbons and is a net exporter of oil and natural gas, particularly for the European markets. Natural gas plays a major role for supplying energy in the residential and industrial sector.

The industry is one of the most developed sectors in Azerbaijan. It covers fuel and energy, chemistry, mechanical engineering, metallurgy, food industry, light industry and other areas. Industry plays a very important role in the development of country's economy. As regards the GDP, the industrial sector has the largest share with 61.1%, followed by the services sector (32.5%)[35].

The number of active industrial enterprises in 2016 amounted to 2,561, out of which 1,209 are medium and large companies and 1,352 are small companies[36].

The most energy consuming sector in the country is the household sector (40.5% of the final consumption) followed by the industry and construction (24.9%) and transport (23.6%) sectors. Other branches of economy represent the rest 11.0%[37].

The final energy consumption in the industrial sector is constantly increasing during the last 5 years; in 2016, the final energy consumption reached 1,563.5 ktoe or **18,184 GWh**, as it can be observed from the Figure 3-2.

[34] comprising 874 kt of food and 645 t of drink
[35] https://theodora.com/wfbcurrent/azerbaijan/azerbaijan_economy.html (2016 data)
[36] Industry of Azerbaijan, Official publication, Statistical yearbook, 2017
[37] Energy of Azerbaijan, Official publication, Statistical yearbook, 2017

Figure 3-2: Final energy consumption in industry in Azerbaijan (2012 – 2016)[38]

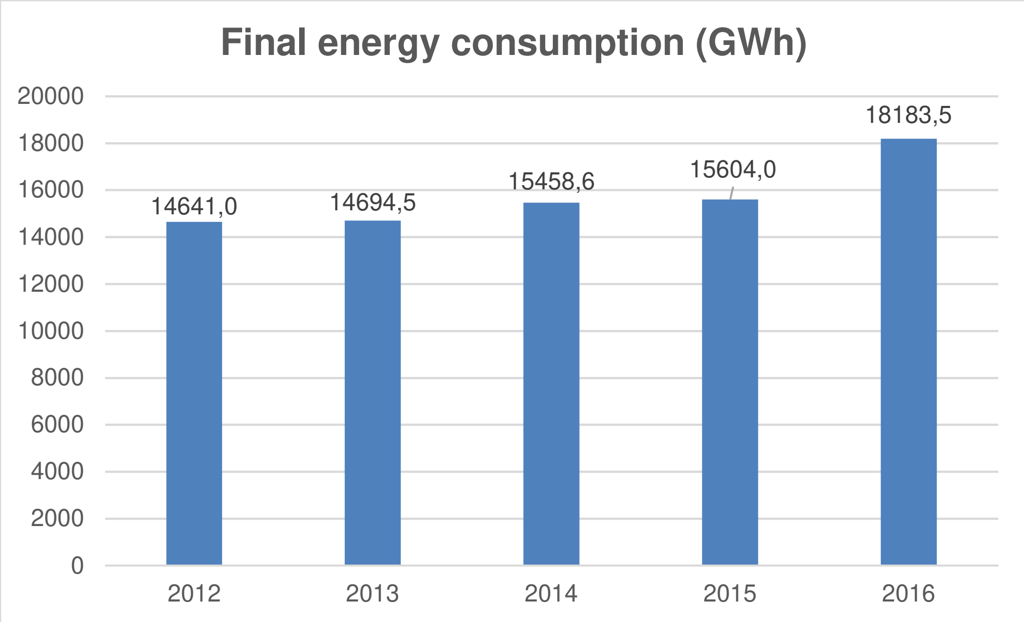


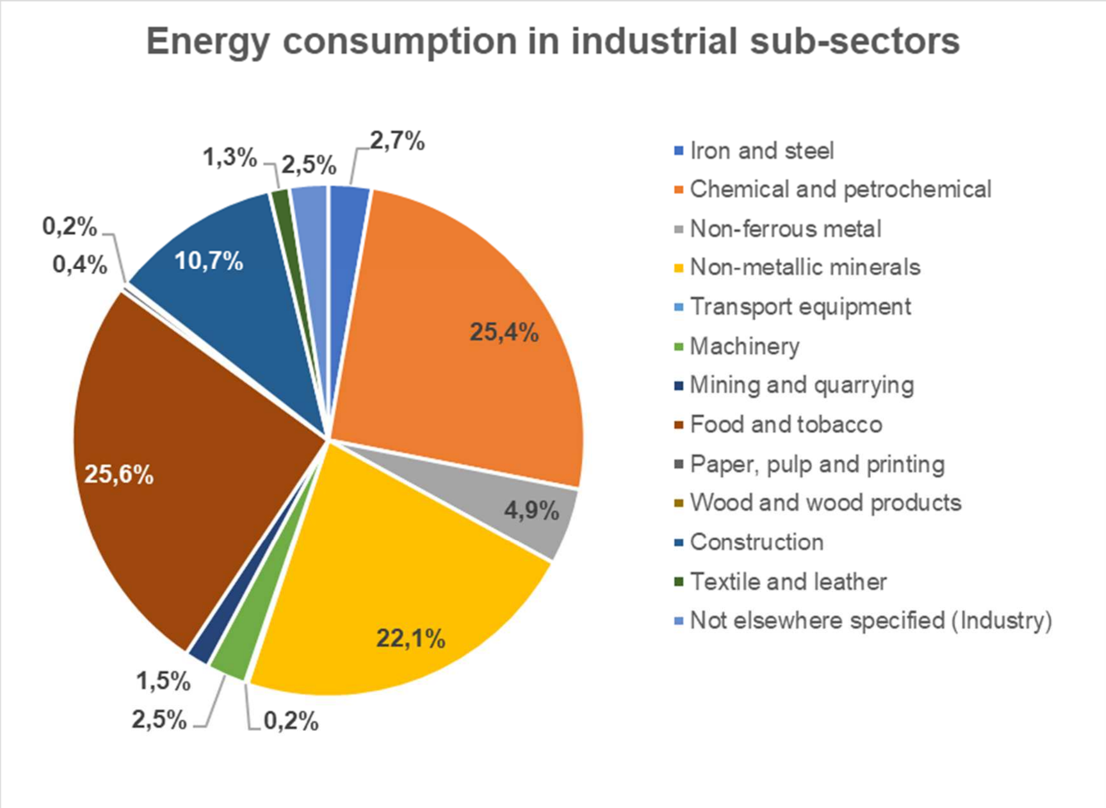
Table 3-4 presents the energy consumption in the main industrial sectors in Azerbaijan and Figure 3-3 depicts the share of its sub-sector in the total energy consumption.

Table 3-4: Energy consumption in the industrial sectors in Azerbaijan (2016)[39]

Industrial sub-sector	Energy consumption (GWh)
Iron and steel	495.4
Chemical and petrochemical	4,612.5
Non-ferrous metals	886.2
Non-metallic minerals	4,027.5
Transport equipment	32.6
Machinery	460.5
Mining and quarrying	281.4
Food and tobacco	4,657.8
Paper, pulp and printing	67.5
Wood and wood products	32.6
Textile and leather	229.1
Construction	1,953.8
Not elsewhere specified (Industry)	446.6
TOTAL	**18,183.5**

38 Energy of Azerbaijan, Official publication, Statistical yearbook, 2017
39 Energy of Azerbaijan, Official publication, Statistical yearbook, 2017

Figure 3-3: Share of the energy consumption among the industrial sub-sectors in Azerbaijan



As it can be observed from the above table and figure, the most energy consuming sectors are:

- **Food and tobacco**, representing almost 26% of total energy consumption
- **Chemical and petrochemical**, representing approximately 25.5% of total energy consumption
- **Non-metallic minerals**, representing approximately 22%, and
- **Construction**, with a share of almost 11% in the total energy consumption.

Table 3-5 presents estimates of production in the industrial sector. Table 3-6 depicts an effort to present the specific energy consumption in the sub-sectors where data is available.

Table 3-5: Estimates of production in the industrial sector in Azerbaijan[40]

Industrial sub-sector	Approximate production (tons)
Mining and quarrying	42,880,000
Food and beverages[41]	5,313,818
Chemical and petrochemical	5,545,400
Paper, pulp and printing[42]	16,100
Non-metallic minerals	3,793,500
Non-ferrous metals	104,287,200
Transport equipment	1122 (units)

[40] Industry of Azerbaijan, Official publication, Statistical yearbook, 2017
[41] The production refers only to food and beverages
[42] The production refers only to paper and carton products

Table 3-6: Specific energy use in selected sub-sectors in Azerbaijan

Industrial sub-sector	Specific energy use (kWh/ton)
Mining and quarrying	6.6
Food and beverages	876.5
Chemical and petrochemical	831.8
Paper, pulp and printing	4,189.7
Non-metallic minerals	1,061.7
Non-ferrous metals	8.5
Transport equipment	29,023.2 kWh/unit

The calculated specific energy use in the industrial sectors of both Georgia and Azerbaijan refer to each sector as a whole, based on data provided by the statistical committees / offices of both countries. The specific energy use was not possible to be split further in sub-sectors due to lack of available data. In this respect, the specific energy use is very difficult to be compared to international or EU benchmarks which refer to sub-sectors or processes in each industrial sector.

4 Energy audits in SMEs in Georgia and Azerbaijan

4.1 Introduction

Under Component 3 of the project, the Study Team has to perform walk-through energy audits in industries in Georgia and Azerbaijan. Considering the type of auditing (walk-through audits) and the time limitation of the audits, the Study Team considered the following criteria for selecting the industries:

> **Replicability**: the EE measures that will be proposed should have replicability or, at least, attract the interest of as many as possible similar enterprises in the country. In this respect, selection of SMEs is the preferable option, since large scale, energy intensive industries are technology-specific and replicability of EE measures is very limited.
> **Effectiveness of the audits**: Given the time limitation for conducting the energy audits, it is more effective to audit an SME rather than a large industry which would require more resources to conclude to useful recommendations.
> **Acceptance and data availability**: It is important that the management of each industrial facility to be audited will recognise its benefit from the audit, accept to avail all necessary data prior to the audit and commit specialised staff to collaborate with the auditors during the audit.

In **Georgia**, since 2014, 18 energy audits have been performed in SMEs in the framework of the UNIDO demonstration component of the EU's program Greening Economies in the Eastern Partnership Countries (EaPGREEN) project "Resource Efficient and Cleaner production (RECP). The Study Team considered this as a good opportunity to sought synergies and capitalize the work conducted. In this respect, the Study Team performed walk-through energy audits in 3 of these SMEs with the aim to **check** / **verify the findings** of the energy audits performed during

the previous project and **identify the reasons / difficulties of non-implementation**. The industries that were selected belong to the sectors of food & beverage (**2 industries**) and paper manufacturing (**1 industry**). The selection of these 3 industries is based on the fact that a) the food & beverage sector is considered the one with the greatest opportunities for EE improvements in the country, b) these 3 companies have a typical technology level and c) their management is ready to provide the necessary data and accept the Study Team to perform the walk-through energy audits.

In **Azerbaijan**, a different approach was followed. The Study Team **contacted 20 industries**, belonging most of them to the SME sector. The industries contacted, belong to the following sectors:

- Manufacturing of wood products
- Manufacturing of plastics
- Manufacturing of electrical equipment
- Basic metals
- Food products
- Making paper products
- Manufacture of glass products
- Manufacture of chemicals and paints
- Manufacture of metal products
- Manufacture of wearing apparel
- Manufacture of cement.

It seems that the interest and willingness to perform energy audits was very limited in Azerbaijan since, from the 20 companies contacted, only 2 SMEs responded positively belonging to the sectors of manufacturing of wood products and manufacture of plastics. This is mainly attributed not only to the low awareness on EE from the top management but also from the general feeling that EE is not a high priority at the moment.

Prior to the site visits, the Study Team prepared a structured questionnaire for data collection purposes and sent it to the respective industries. The scope of the questionnaire is to record and breakdown the electric and thermal consumption of each facility among the primary and auxiliary systems installed, the annual costs for energy consumption, and the specific characteristics of the equipment. The template questionnaire can be found in **ANNEX 1**.

The visits in the **3 industries in Georgia** were performed during the period of 26-29 September, while the visits to the **2 industries in Azerbaijan** were performed during the period of 10-12 October.

General findings of the walk-through energy audits are presented in the next chapter. The energy audit reports of the 5 industries are presented as separate attachments.

It is noted that the names of the companies are confidential and are marked as Company A, B, C, D and E.

4.2 Energy audit findings

The missions identified the following findings:

- Lack of financing;
- Limited policies and enforcement;
- Limited information (in some cases limited knowledge);
- Low level of management awareness on EE;
- Obsolete and inefficient equipment.

It is noted that these findings have been accrued during the discussions with the management of the industries that were visited.

Lack of financing

The most common barrier is the **lack of funds** to invest in EE technologies and **access to financing**. EE investments with a payback period of more than 2 or 3 years were rarely implemented. Some EE investments provide significant savings and a short payback period of often less than one year, but the investment is costly and the company simply do not have available the funds to invest or to is not able to receive any financial support from national financial institutions.

It was reported that in **Georgia**, the local financial institutions are hesitant and not much interested to provide loans for EE investments requiring a lower budget (most EE investments in the SME sector require loans between 8,000 to 35,000 EUR[43]). Only Procredit bank has a separate department for providing loans to green investments. Additionally, interest rates are high, and banks often do not have confidence in the creditworthiness of the clients to give them a loan. Other companies feel uncomfortable to take a loan, and these are often family-run businesses that are used to saving money rather than proceed with EE investments.

In **Azerbaijan** on the other hand, it was reported that since energy tariffs are highly subsidized, results in discouraging the development of the EE market and attracting potential investors. On the other hand, there are some programmes that provide low-interest loans in the order of 6% (compared to the national financial institutions that provide loans with 14% interest rate). It is noted however, that the regime for taking such loans is very complicated and unclear.

Limited policies and enforcement

Lack of effective policies is a key issue, but the situation is different between countries. **Georgia** has not put in place any legislation yet specifically targeting EE in the industrial sector. However, references to the need to improve EE are scattered across a number of legislative instruments, which highlight the significance of incorporating EE measures in the national economy. Georgia however, recently accessed the Energy Community and is in the process of implementing the EU energy legislation by gradually transposing the EU's relevant directives. More significantly, the country is currently in the final stages of adopting the first National Energy Efficiency Action Plan (NEEAP), which has been elaborated in accordance with the provisions of the EE Directive (2012/27/EC)[44]. The NEEAP sets the country's indicative national EE targets for 2020, 2025 and 2030 and also estimates expected energy savings and GHG emissions reduction by measures according to each sector. However, its preparation will need to be supplemented with a substantial

---

[43] Interview with Green Investment Expert of UNIDO (Georgia)

[44] This step of the country's first NEEAP is a requirement both for EU Member States under the EU Energy Efficiency acquis and for the EnC Contracting Parties.

array of additional policy and incentives measures in order to be consistent with the relevant EU norms and practices.

On the other hand, **Azerbaijan**, is a major exporter of oil and natural gas resulting in the application of low energy tariffs in the domestic market. In this respect, **EE is not considered as a high priority** and EE legislation is poor. However, EE considerations are included in several pieces of legislation and legal documents, but a coherent and concrete EE strategy at both the policy and regulatory levels is still missing.

Another problem is the weak enforcement of environmental policies and legislation. A reason for this limited enforcement is that the Governments of both countries allocate insufficient funds for policy implementation and enforcement. Additionally, in the case of Georgia, local authorities are often hesitant to incur fines to companies, being afraid that they might move their industrial activity to other parts of the country or to the other countries, and thereby causing a loss of local jobs.

But most crucial that hinders industry's energy efficiency potential are government policies that are only aimed at short-term rapid economic gain ignoring the environmental impacts and therefore are a threat to long-term economic and social development. The most common example applicable to both countries is government subsidies of oil products. With the increasing energy needs to sustain their economic growth, these subsidies comprise a significant share of the national budget. The only way to achieve energy security is for the governments to support and subsidize EE and RE investments limiting in parallel the subsidies of imported oil products.

Limited information and knowledge

Poor data collection systems were the main cause of lack of electricity and resource consumption data. Almost all SMEs in both countries only had one meter to measure electricity, natural gas and water consumption for the entire plant.

Different departments often hold different information, but no one has the overview to manage resource and energy consumption effectively. Information is not always communicated to those who can influence resource consumption.

Limited internal knowledge and expertise (lack of training and limited procedures/documents) was also a common problem. A minimum technical knowledge of energy, production processes and equipment are required to be able to identify, investigate and implement options to reduce energy losses and improve resource and EE.

Several SMEs had difficulties in accessing external information and expertise. Sometimes this was caused by lack of internet access (only senior management have internet connection) and very often by language barriers (often only senior management speak English and sometimes even they did not).

The missions also highlighted that external information on EE is scattered because, so many organizations hold a piece of the puzzle, including ministries, international organizations, consultancies, etc. This makes it difficult for a company to get a clear overview of available information or even to know where to start looking.

Low level of management awareness on EE

During our discussions with the top management of the SMEs, it was evident the lack of awareness on EE. Lack of awareness appears to be the root cause of other barriers, such as the priority for production, lack of investment capital, and limited policies, systems and reporting processes to manage energy consumption, and hierarchical management structures.

In both countries it was reported that the top management is focused mainly in maximizing the production output and turnover rather than on producing safely, more energy efficiently and reducing production costs resulting in difficulties in energy assessment and option implementation. For instance, in both countries, energy costs are rather low representing a very small percent to the overall production cost thus the application of EE technologies for cost reduction is not considered much important.

Many SMEs consider the protection of the environment as a legal compliance issue and cost burden instead of an opportunity to reduce costs.

Usually top management often considers new technologies as the only way to significantly improve resource efficiency and pay less attention on low cost and good housekeeping opportunities.

Lack of awareness of management on resource and energy efficiency is also caused by the immature systems to manage energy, such as policies, environmental management systems, and the delegation of an energy or environment manager. Therefore, top management is not sufficiently informed on energy-related aspects and consequently cannot be pro-active towards energy management. In addition, without management systems, the staff is less able to take initiatives to reduce energy consumption.

Obsolete and inefficient equipment

During the walk-through energy audits, it was noted that most of the companies operate with obsolete and non-efficient equipment. This equipment relates not only to horizontal technologies such as the steam generation systems, the compressors and the compressed air systems but also to process-specific technologies.

According to the discussions held, the main reason for not replacing the old equipment is the lack of funds to invest in EE technologies and access to financing. In addition, the focus of the industries' management is mainly to increase their productivity rather than minimizing their production costs.

5 Energy efficiency measures applicable to industries in Georgia and Azerbaijan

5.1 Introduction

This section presents cross-cutting / horizontal EE technologies that can be applied in almost all industrial sectors in Georgia and Azerbaijan. Focus is given in horizontal EE technologies instead of EE technologies in each industrial process since each industrial sector has specific process lines and the EE measures that can be applied are sector-specific, more complex in nature and require major investments.

In the following paragraphs, the most appropriate EE measures in cross-cutting technologies and potential energy savings that can be achieved are presented.

5.1.1 Electricity supply and consumption

Electricity supply in both countries is provided by a few national, vertically integrated utilities. Industries normally cover their entire electricity from the public grid.

The pricing of electricity is regulated, and prices are published in the bulletins of the utilities. There are no negotiated electricity supply contracts between the utilities and the companies.

A highly effective measure to save electricity cost is **load management**. This can be done by shutting off “non-critical” consumers (load shedding) for a short time during the electricity peak of the day. Finally, non-critical consumers must be identified in close cooperation with the company staff.

In many factories the peak demand incurs during the start-up of production. In such cases, load management is quite easy and can be a “no-cost” measure. If the peaks occur at irregular times, sophisticated automated systems should be introduced.

5.1.1.1 Energy saving measures

Potential energy saving opportunities are:

- Shut-off sections which do not require electricity when in operation;
- Shifting loads to the off-peak times;
- Load management;
- Installation of soft starters in large motors to avoid peaks at start-up times;
- Replacement of excessively oversized transformers;
- Cogeneration; a precondition is the coincidence of electricity and the relatively high demand for steam.

Additionally, more that 70% of the total site electricity is used for motive power, therefore motor energy saving techniques need to be practiced. Some ideas for good motor management are:

- Soft start power optimizer;
- Installation of variable speed inverter control;
- Use of high efficiency motors when replacing old and broken-down ones;
- Utilize motors near its rated capacity;
- Turn off any equipment when not in use.

5.1.2 Steam generation and distribution

Electricity and steam are the most important energy types in industries. In most cases, shell type fired tube boilers are used for steam generation. The produced steam is supplied for the users within the factory via a distribution network consisting of a steam supply and condensate return pipeline. Energy saving opportunities can be found in both the boiler plant and in the distribution network.

Modern fuel oil or natural gas fired boilers can achieve overall efficiencies of more than 90%. However, in many cases they are not properly operated, and the actual efficiency is low. The main losses involve flue gases, carbon monoxide (CO), casing and blow down losses.

Most important are the flue gases losses, which are normally caused by an extremely high excess air ratio and flue gas temperature. Modern boilers fired with clean fuels like light fuel or natural gas can be operated with excess air ratio lower than 10% and exhaust gas temperature lower than 200ºC. Using a gas analyser, the actual operating conditions can be checked. Periodic re-adjustment of the burner is recommended.

The cause for extremely high flue gas temperatures is in most cases the unclean heating surfaces. The rule of thumb is that **an increase of 20ºC in the flue gas temperature will result in 1% lower efficiency**. In older boilers, retrofitting with economizer to preheat boiler feed water should be considered. The rule of thumb is that **for every 6ºC rise in the feed water temperature there will be approximately 1% saving of fuel in the boiler**. While flue gas recovery is an effective method of energy recuperation, its potential is limited depending on the sulphur content within the fuel burned. Furthermore, the lower exit temperature for the flue gas must be above 150ºC, as the sulphur within the flue gases will condense on the heat exchange ducts which in turn lead to the pipes corrosion.

CO content in the flue gas is an indication of an incomplete and inefficient combustion. Ideally there should not be CO in the flue gas. Consider that **only 0.25% CO content will result in 1% lower efficiency**.

Boiler blow down is a part of the steam generation process and is a normal loss provided that the water quality is adequate and quantity of blow down is not excessive. Heat can be recovered from boiler blow-down by using a heat exchanger, a flash steam recovery vessel, or a flash steam recovery vessel in combination with a heat exchanger to preheat boiler makeup water. Recovering flash steam from continuous blow-down can reduce the energy loss by up to 50% to give an energy saving of **0.5 - 2.5% of the boiler heat input.** Using heat exchangers to recover heat from the remaining liquid blow-down can provide a further saving of around 25% to give an overall energy saving of **0.75 - 3.75% of heat input**.

Boiler feed water must be properly treated and is quite expensive. Therefore, **the return rate of clean condensate must be as high as possible**. Clean condensate does not need special treatment.

5.1.2.1 Energy saving measures

Steam and high temperature hot water boilers offer many energy savings opportunities which can make significant cost savings to industries. The most appropriate option depends on the type of boiler and heating system, the requirements of the process or other heating demands and budget.

Table 5-1 presents energy saving measures in terms of their effectiveness in reducing energy consumption.

Table 5-1: Energy saving measures in steam generation and distribution

Measure	Energy Savings
Improve combustion efficiency by reducing excess air to minimum ratio, cleaning boiler heat surfaces as soon as flue gas temperature tends to increase[45]	Up to 5% (efficiency increase by about 0.5% for every 1% decrease in O_2)
Boiler and burner management, digital combustion controls and oxygen trim[46]	Up to 5%
Locate and repair steam leaks in fittings, equipment and steam traps[47]	10% - 15%
Insulate pipelines and equipment[48]	3% - 13%
Increase condensate return rate. In case there is no condensate return line at all, consider retrofitting of condensate return line in the whole system or in parts of it where it is financially viable[49]	Up to 10%
Retrofit the boiler with economizer and recover flue gas heat, if flue gas temperature remains high, after cleaning (economizers are usually viable for boilers with a capacity of over 3 MW)[50]	5%, up to 15% for condensing boilers
Install VSDs for fans, blowers and pumps[51]	Up to 50% of energy use are achievable by reducing the fan or pump motor speed by 20%
Boiler and burner management, digital combustion controls and oxygen trim[52]	Up to 5%
Make use of waste heat from production processes to preheat combustion air	Case specific
Boiler replacement if the existing boiler is excessively oversized and outdated	Case specific
Use of alternative fuels such as biomass	Case specific
Improve housekeeping and maintenance	Case specific

5.1.3 Compressed air

Compressed air is widely used in industrial sites although it is a very expensive source of energy. The overall efficiency of compressed air systems is very low, only about 5% to 8% of the electrical energy input converted into useful energy. Therefore, the use of compressed air should be limited, applied only where it is absolutely necessary and cannot be replaced by a different energy form e.g. electricity. Often factory operators are not aware about the production cost of compressed air.

At large and medium sized industrial sites, compressed air is generated at a central station consisting of several compressor units and supplied to the individual users via a distribution system. **It is important to know that compressors in idling operation consume about 1/3 of their rated power**. The cause of idling operation may be an oversized compressor, too high

[45] http://www.ecoen.co.in/boiler.html
[46] https://www.carbontrust.com/media/13332/ctv052_steam_and_high_temperature_hot_water_boilers.pdf
[47] Spirax Sarco, Optimising steam system Part I
[48] Spirax Sarco, Optimising steam system Part I
[49] https://energy.gov/sites/prod/files/2014/05/f16/steam8_boiler.pdf
[50] https://www.carbontrust.com/media/31715/ctg057_heat_recovery.pdf
[51] Carbon Trust, Motors and Drivers, CTV048
[52] https://www.carbontrust.com/media/13332/ctv052_steam_and_high_temperature_hot_water_boilers.pdf

operating pressure or a poor control system. Idling time is checked by metering the electricity output so that it is not long. The operating pressure should also be reset to the lowest possible value, while ensuring an efficient control system is in place. A compressor that is excessively oversized should be considered for replacement.

It is worth mentioning that **the reduction of the operating pressure from 7 bar to 6 bar for example, will result in electricity cost savings of about 6% to 10%**. This will also reduce compressed air leakage rate by 10%. Pre-cooling of the inlet air can also bring substantial savings. The rule of thumb is that **4ºC lower inlet temperature results in 1% increase in efficiency**. Reduction of pressure in branches of the distribution system by installing of throttle valves will also result in substantial savings.

Leakages in the distribution system usually do not have adverse impact on the production process; are not visible and in most cases remain undiscovered by the factory staff. Consider that one leakage of only **1 mm in diameter can result in additional operational costs of about 90 EUR per year**. An ultrasonic leakage tester can be used to locate leakages and the factory staff must be instructed on the use of this equipment in order to assess the magnitude of air leakages (a "no load test" shall be conducted).

Compressed air distribution systems shall be designed for a pressure drop of about 0.1 bar from the station up to the final user. By extension of the system in old factories the pressure drop may be higher and should be checked. Recalculation of the distribution system to eliminate bottlenecks should also be considered.

5.1.3.1 Energy saving measures

Table 5-2 presents energy saving opportunities in compressed air systems.

Table 5-2: Energy saving measures in compressed air systems

Measure	Energy Savings
Turn off the back-up compressor until it is needed and during non-working time	Case specific
Conduct leakages test periodically and repair leakages[53]	~ 20%
Consider alternatives to compressed air such as hydraulic rather than air cylinders, electric rather than air actuators and electronic rather than pneumatic controls	Case specific
Identify real pressure requirements of users, set user pressure as low as possible and reduce air compressor discharge pressure to the lowest acceptable setting	Reduction of the operating pressure from 7 to 6 bar for example, will result in electricity cost savings of about 6% to 10%
Identify branches of the distribution system with users of lower pressure requirements and consider retrofitting throttle valves	Case specific
Consider installation of a control system to optimize operation of unit station[54]	~ 12-15%
Consider variable speed drive (VSD) for variable load on positive displacement compressors[55]	~ 2%

[53] Reference document on best available techniques for energy efficiency, February 2009

[54] Reference document on best available techniques for energy efficiency, February 2009

[55] Reference document on best available techniques for energy efficiency, February 2009

Measure	Energy Savings
Consider cooling intake air	4°C lower inlet temperature results in 1% increase in efficiency
Consider heat recovery at very large compressors[56]	~ 20-80%
Keep air treatment to the minimum possible	Case specific
Eliminate bottlenecks causing excessive pressure drop in the distribution system	Case specific

5.1.4 Electric motors

Many devices in industries such as fans, pumps, conveyors and power tools are predominantly driven by electric motors. In general, electric motors have varied efficiency ratings that range from 60% to 95%, depending on the motor size and operating conditions. The most common application in industries is AC-three phase induction motors, which should be sized and operated near to full load conditions. Short time operation under overload up to 50% of the rated capacity does not damage the motor if the maximum load is not exceeded. However, at part load operation under 50%, the efficiency of motors may drop significantly while reactive power increases resulting in excess power consumption and cost.

For oversized electric motors, three possibilities for reduction of the power input can be considered:

- Continuous operation in star instead of delta connection;
- Application of VSDs;
- Replacement of excessively oversized motors.

Replacement of oversized electric motors is in most cases not a financially viable solution; therefore, proper sizing of new motors is very important. High efficiency motors should be considered for drives at high loads for long periods.

Induction motors operating at a constant speed while the required volume flow is adjusted by throttling or by-pass controls, result in significant amounts of energy wastage. In such cases and for variable loads, consider the application of VSDs resulting in energy savings.

5.1.4.1 Energy saving measures

Table 5-3 presents energy saving opportunities in electric motors.

Table 5-3: Energy saving measures in electric motors

Measure	Energy Savings
Make use of gravity instead of pumping wherever possible	Case specific
Operate pumps, fans and blowers near the best efficiency point	Case specific
Consider replacement of impellers or turning-down of the diameter of impellers to reduce throttling and power input	Case specific
Consider use of smaller motors after optimizing devices	Case specific

[56] Reference document on best available techniques for energy efficiency, February 2009

Measure	Energy Savings
Consider sequence control of smaller and VSD for large unit whenever there is wide load variation	Case specific
Consider the installation of high efficiency motors for near continuous operation over the year	Case specific

5.1.5 Pumps

In industrial and commercial applications, pumps are used to move fluids such as:

- Chilled water through the chillers and air handling units
- Cooling water through the condensers and cooling towers
- Water supply from a source to an overhead tank or pressure tank
- Drainage from a basin to the main drainage lines
- Sewage from a sump to the main drainage lines

The importance of pumps to the daily operation of buildings and processes necessitates a proactive maintenance programme. Most pump maintenance activities centre on checking packing and mechanical seals for leakage, performing preventive or predictive maintenance activities on bearings, assuring proper alignment and validating proper motor condition and function.

Some points to be considered for improving pump efficiency are the following:

- *Excessive pump maintenance*: this is often associated with oversized pumps that are heavily throttled, badly worn pumps and pumps that are misapplied for the present operation;
- *Pump systems with large flow or pressure variations*: when normal flows or pressures are less than 75% of their maximum, energy is probably being wasted from excessive throttling, or operation of unnecessary pumps;
- *Throttled control valve:* the pressure drop across a control valve represents wasted energy that is proportional to the pressure drop and flow;
- *Noisy pumps or valves*: a noisy pump generally indicates cavitation from heavy throttling or excess flow. Noisy control valves or bypass valves usually mean a higher-pressure drop with a corresponding high-energy loss;
- *Multiple pump systems*: Energy is commonly lost from bypassing excess capacity, running unneeded pumps, maintaining excess pressure or having a large flow increment between pumps;
- *Pumps with known overcapacity*: Overcapacity wastes energy because more flow is pumped at a higher pressure than required.

5.1.5.1 Energy saving measures

Table 5-4 presents energy saving opportunities in pumping systems.

Table 5-4: Energy saving measures in pumping systems

Measure	Energy Savings
Shut down unnecessary pumps	-

Measure	Energy Savings
Trim or change impellers if head is larger than necessary[57]	Case specific
Replace oversized pumps with more efficient models[58]	1-2%
Use multiple pumps instead of one large one	Case specific
Change the speed of a pump for the most efficient match of horsepower requirements with output[59]	5-40%

5.1.6 Lighting systems

Lighting can be one of the biggest energy consumers in industrial premises, especially in the office areas. Although, good visibility is an important issue for any working environment and production area, lighting systems do not always operate in an energy efficient way. Energy for lighting is often wasted, because:

> Lighting systems are generally in bad technical conditions;
> New technologies that offer higher lighting levels with lower energy input are not being used;
> The lighting system originally installed, does not meet the changed working environment

5.1.6.1 Energy saving measures

Table 5-5 presents energy saving opportunities in lighting systems.

Table 5-5: Energy saving measures in lighting systems

Measure	Energy Savings
Use of high efficiency lamps and luminaires[60]	~ 75% from incandescent to LED lamps and ~45% from T12 to T5
Change high-pressure mercury lamps against metal halide lamps	-
Implement automatic time switches and motion detectors	-
Use electronic ballasts[61]	~ 20%
Implement modern lighting management systems[62]	~ 30 - 50%

5.1.7 Industrial refrigeration and cooling[63],[64],[65],[66]

About 10% of the industrial energy consumption worldwide is used for refrigeration and cooling systems. The most important applications of cooling systems are used widely in industry, logistics, storage and trade.

[57] https://www1.eere.energy.gov/manufacturing/tech_assistance/pdfs/trim_replace_impellers7.pdf
[58] Energy Efficiency Best Practice Guide, Pumping Systems, Sustainability Victoria
[59] Energy Efficiency Best Practice Guide, Pumping Systems, Sustainability Victoria
[60] https://energy.gov/energysaver/led-lighting & http://greensavingsco.com/2009/12/changing-from-t12-to-t5/
[61] Taking Action on Climate Change, Long term mitigation scenarios for South Africa, Harald Winkler, 2010
[62] https://www.carbontrust.com/media/13067/ctv049_lighting.pdf
[63] Carbon Trust “How to implement heat recovery in refrigeration – CTL056”
[64] Carbon Trust “Refrigeration systems, Guide to energy saving opportunities, CTG046, 2008”
[65] Roxburgh Mark “Mercury Technologies Ltd, Industrial Refrigeration – energy saving opportunities”
[66] Carbon Trust “Refrigeration systems, Best Practice Northern Ireland – CTG024”

In general, passive and active cooling methods are being used. In comparison to active cooling systems that use energy for a refrigerant or cooling system to cool warm air, passive cooling systems do not use a refrigerant. Those refrigeration systems are primarily used in food and plastics industry as well as air conditioning systems.

Refrigeration plants are not only costly to build, but they are also expensive to operate, primarily due to their high energy consumption. Typical refrigeration systems may have a lifetime operating cost 7 to 10 times greater than their initial investment cost.

Heat recovery from a refrigeration system is recommended when there is demand for hot air or water close to the refrigeration site and when that demand coincides with the working time of the cooling plant. When installing a heat recovery equipment to an existing refrigeration plant, the amount of energy recovered can be up to 30% of the cooling capacity. However, the installation of such equipment isn't viable to compressors with electrical load below 30 kW.

EE on refrigeration systems can be achieved by improving system controls using screw compressors or increasing temperature levels on the cold side and reducing temperature levels on hot side. A rule of thumb is that for each degree change in temperature, electricity consumption can be reduced by 2% to 4%.

Automated leak detection systems with single or multiple sensing devices to monitor different locations can be used to identify and minimize possible leakages. These systems can save up to 15% of energy costs for refrigeration.

5.1.7.1 Energy saving measures

Table 5-6 presents energy saving opportunities in industrial refrigeration and cooling.

Table 5-6: Energy saving measures in industrial refrigeration and cooling

Measure	Energy Savings
Refrigeration load reduction	Case specific
Condenser – heat recovery	Up to 30% of the cooling capacity
Improving system controls	2% to 4% for each degree change in temperature
Reducing refrigeration leakage[67]	Up to 15%
Use of high efficiency compressors – increase the compressor size[68]	~ 10% of energy use by increasing the compressor size by 30%
Use of high efficiency fan motors	-
Good housekeeping of refrigeration plants[69]	Up to 10%

5.1.8 Furnaces, kilns and ovens[70],[71],[72]

Industrial furnaces are used for burning, melting, heating, casting and forming for thermal treatment, sintering and calcinations. Industrial furnaces are classified according to the type of construction (box furnace, hood-type furnace, blast furnace, rotary furnace, tunnel kiln) and type

[67] Carbon Trust "Refrigeration systems, Guide to energy saving opportunities, CTG046, 2008"
[68] Carbon Trust "Refrigeration systems, Guide to energy saving opportunities, CTG046, 2008"
[69] https://www.carbontrust.com/resources/guides/energy-efficiency/refrigeration/
[70] US DoE "Office of Industrial Technologies, Roadmap for Process Heating Technology, 2001
[71] US DoE "waste heat reduction and recovery for improving furnace efficiency, productivity and emissions performance, 2004"
[72] Reference document on Best Available Techniques for Energy Efficiency, Feb. 2009

of heating (electrical heating, fuel heating). Furnaces, kilns and ovens are used in metal industry, non-ferrous industry, ceramic industry, glass industry and food and beverage industry.

Optimizing combustion air is one of the most economical means of saving energy in a furnace or kiln. Complete combustion of fuel with minimum amount of air is ensured by controlling air filtration, maintaining the pressure of combustion air, ensuring high fuel quality and monitoring the amount of excess air. Energy savings of 5% - 25% can be achieved.

It is important to operate the heating devices at its optimum temperature. This can be done by introducing automatic control, which results in energy savings of 5% - 10%.

One of the most important factors affecting furnace efficiency is the load. Furnaces, kilns or ovens should be operated at full capacity (loaded to the optimal load) at all times to keep the specific use of energy for production processes at a low level. Furnace efficiency increases in line with production up to the design point.

High temperature heat recovery systems (recuperators or regenerators) can be used to recover heat from flue gases (they carry 35% to 55% of the heat input to the furnace). Typical savings between 10% and 30% can be achieved using heat recovery systems.

Around 30% of the fuel used in furnaces is used to make up for heat lost through the furnace's surfaces or walls. Heat losses can be reduced by:

- Keeping the openings as small as possible
- Opening the furnace doors less frequently and for the shortest period

Heat losses can be reduced by 2% to 15% of a furnace's fuel consumption.

Finally, refractory materials (bricks) should be selected in order to maximize the performance of the furnace or kiln. For the selection of refractories, the following points should be considered:

- Type of furnace
- Area of application
- Working temperature
- Structural load of the furnace
- Cost

Use of high quality materials is reported to yield energy savings of up to 25%.

5.1.8.1 Energy saving measures

Table 5-7 presents energy saving opportunities in furnaces, kilns and ovens.

Table 5-7: Energy saving measures in furnaces, kilns and ovens

Measure	Energy Savings
Optimization of combustion air[73]	5-25%
Operating at optimum furnace temperature[74]	5-10%
Optimum capacity utilization	Case specific
Use of high temperature heat recovery systems (recuperators or regenerators)[75]	10-30%

[73] US DoE "Office of Industrial Technologies, Roadmap for Process Heating Technology, 2001
[74] US DoE "Office of Industrial Technologies, Roadmap for Process Heating Technology, 2001
[75] Reference document on Best Available Techniques for Energy Efficiency, Feb. 2009

Measure	Energy Savings
Reduction of losses from furnace surface and openings[76]	2-15%
Selecting the appropriate refractories	Up to 25%

5.1.9 Monitoring and Targeting and Energy Management Systems

The purpose of Monitoring and Targeting (M&T) is to relate energy consumption data to the weather, production performance or other measures by providing a better understanding of how energy is being used. In particular, it will identify if there are signs of avoidable waste or other opportunities to reduce consumption.

M&T generally consists of three particular activities: Monitoring, Targeting and Reporting. These component activities are distinct, yet interrelated.

Monitoring is the regular collection of information on energy use. Its purpose is to establish a basis of management control, to determine when and why energy consumption is deviating from an established pattern, and as a basis for taking management action where necessary. Monitoring is essentially aimed at preserving an established pattern.

Target setting is the identification of levels of energy consumption, which is desirable as a management objective to work toward.

Reporting involves "closing the loop" by putting the management information generated from the monitoring process in a form that enables ongoing control of energy use, the achievement of reduction targets, and the verification of savings.

M&T is a part of an Energy Management system applied to industrial processes.

An Energy Management System (EnMS) is required to create a foundation for positive change and to provide guidance for managing energy throughout an organization. The most recognised tool that helps organisations put in place an EnMS and use their energy more efficiently is the ISO 50001 standard.

ISO 50001 standard follows the PLAN, DO, CHECK, ACT cycle. It provides a framework for the continuous improvement of processes or systems. Continuous improvements to EE typically only occur when a strong organizational commitment exists. An EnMS helps to ensure that EE improvements do not just happen on a one-time basis, but rather are identified and implemented in an ongoing process of continuous improvement. Without the backing of a sound energy management program, EE improvements might not reach their full potential due to lack of a systems perspective and/or proper maintenance and follow-up.

The main elements of an EnMS according to ISO 50001 are shown in Table 5-8.

Table 5-8: Main elements of an EnMS according to ISO 50001 standard[77]

Key area	Main issues
Policy	Energy management policy statement
Planning	▪ Significant energy systems identified and reviewed ▪ Measurable energy objectives and targets set

[76] US DoE "Office of Industrial Technologies, Roadmap for Process Heating Technology, 2001

[77] ISO 50001 Standard

Key area	Main issues
	▪ Programme with responsibilities and time framed defined
Implementation and operation	▪ Roles and responsibilities: Energy manger/energy team with job description appointed ▪ Training and Awareness: personnel associated with energy are familiar with EE and EM programme ▪ Communication: Information on energy performance communicated to employees ▪ Documentation and control of documents ▪ Operational control: Instructions on equipment operation, consideration of EE in procurement of equipment and services
Checking-Monitoring	▪ Energy use and costs being monitored and reported ▪ Progress against plan being monitored ▪ Control of records – non-conformity assessment ▪ Internal audit regularly performed
Review	Effectiveness of EMS reviewed by top management

6 Recommendations

This chapter presents the recommendations of the Study Team based on the discussions held during the implementation of the walk-through energy audits. The proposed recommendations are in line with the proposals developed and presented in Component 2 report. The following recommendations have been proposed.

Development of capacity building and training activities on industrial EE

It was evident to the Study Team from discussions held with the management of the SMEs, the lack of knowledge and information on the benefits of EE investments. This lack of knowledge is also noted to other stakeholders such as energy auditors and EE specialist consultants, equipment providers and installers as well as local financial institutions.

In this respect, the Study Team recommends the implementation of capacity building activities to increase the awareness on the benefits of EE investments.

Such capacity building activities can be in the form of training activities, workshops, discussion platforms, working groups, etc. Topics may include technical as well as financial aspects such as energy auditing procedures, measurement and verification techniques, EE technologies, financial appraisal tools and other as deemed necessary. Specifically, for industrial SMEs, training on the optimisation of industrial system and processes can be proved much beneficial. System optimization offers a way for SMEs to quickly realize cost reduction, productivity increase and operational benefits.

Capacity building can be formulated and implemented not only by the competent State authorities, but also through international agencies and donors, IFIs and international partnerships. Recipients of the capacity building activities should be the industry, EE consultants and energy auditors, equipment providers as well as local financial institutions.

Capacity building activities will create a number of highly skilled system optimization experts that can provide the necessary technical assistance for industrial facilities to identify and develop EE improvement projects.

Improvement of the existing legislative framework and introduction of key policy initiatives

The lack of effective policies targeting EE in the industrial sector is noted in both countries; however, as already stated earlier, the situation is different between countries.

Georgia is a Contracting Party of the EnC and is in the process of implementing the EU energy legislation while in Azerbaijan, being an exporter of oil and natural gas, EE is not a priority at the moment.

The Study Team recommends for the State authorities in **Georgia** to prepare the primary EE legislation in order to achieve the goals set out in the first NEEAP. As a first step can be considered the adoption of the Energy Efficiency Law, which will transpose the EE Directive (2012/27/EU).

On the other hand, in **Azerbaijan,** the State authorities should focus on the consolidation of the existing laws that affect EE investments into a single legislative act. This act can serve as legal basis for drafting and adopting any secondary legislation in relation to EE.

Key policy initiatives that can be applied in both countries are:

- adoption and implementation of internationally accepted standards on energy auditing and energy management;
- implementation of Energy Management Systems by large industries based on widely acceptable standards, such as the ISO 50001;
- conducting energy audits by industrial operators;
- establishment of an accreditation and certification body for energy auditors;
- imposition of minimum energy performance standards on industrial operators;
- development of industrial clusters / networks on EE.

The improvement of the legislative framework and the introduction of key policy initiatives in both countries will provide mainly to industries and potential investors a functioning and sustainable local EE market, untapping in parallel the country's large energy savings' potential.

Formulation of fiscal and financial EE instruments

All stakeholders who have been interviewed mentioned that the **lack of financial resources** and **access to financing** is the most common barrier for EE investments. In this respect, the Study Team recommends for both countries to support industries with targeted programmes of fiscal and financial nature, which will lower the high costs of development of EE industrial projects, enhance local access to EE technologies, products and equipment. Financial and fiscal incentives might include:

- **subsidies** or **grants** provided by programmes developed by State authorities to carry out energy audits and/or the purchase of EE related equipment and products;
- the provision of **loans** provided by local financial institutions to subsidize part of the capital cost of some EE interventions;
- investment **credits** or State-backed **guarantees** for the implementation of EE upgrades or for the adoption of proven EE technologies by industrial operators; etc.
- **tax refunds, deductions, rebates or profit-tax credits** provided by State authorities.

Financial support from State authorities and international financial institutions **will also be needed in order to provide technical training and capacity building to various stakeholders' groups** (EE consultants, local financial institutions, industry, etc.), support the research, development, demonstration and deployment of EE technologies, including the realisation of pilot projects, improving information dissemination and raising general awareness on the benefits of EE investments in industry.

Monitoring of the implementation of policies and measures

As already mentioned in Component 2 report, the Governments of Georgia and Azerbaijan should develop policies, initiatives and programmes with specific time horizons in order to support the implementation of EE measures in industry and especially in SMEs.

However, monitoring of these policies and programmes is an important aspect so as to accurately assess and track the progress on the level of their implementation. The Governments of both countries will play a decisive role in this respect. They should allocate responsibilities to authorized state institutions responsible for the industry sector involving in parallel relevant state institutions, local self-governments, energy efficiency centres, industry associations and other stakeholders.

The Study Team recommends making the monitoring system obligatory in Georgia since Georgia has recently joined the Energy Community Treaty as a Contracting Party and all Energy Community Acquis, including the Energy Efficiency Directive (which contains obligations to monitoring and reporting requirements), must be transposed and implemented. The monitoring system is also proposed to be established in Azerbaijan, even if the country has no obligations yet to adopt the EU EE acquis.

Annex I – Template questionnaire

Directorate General for Neighbourhood and Enlargement Negotiations – DG NEAR

Short term high quality studies to support activities under the Eastern Partnership HiQSTEP PROJECT

Energy efficiency in industrial sectors in Georgia and Azerbaijan

ENERGY AUDIT QUESTIONNAIRE

HiQSTEP Project

September 2017

Note:
All information provided herein by your company will be treated as strictly confidential. All data and other responses will only be used in an aggregate format without a reference to a specific entity. Responses will not be quoted or made public otherwise without consent.

GENERAL INFORMATION

Company	
Address	
General Manager	
Contact person	
Telephone, fax, E-mail	
Date	

Cost Structure

Raw material (%)	
Labour (%)	
Energy (%)	
Other (%)	

1. SITE DESCRIPTION

Products and raw materials
Please provide a brief description including: > *Production of final products and quantities* > *Consumption of raw materials and quantities*

Total annual operating time (h/yr)	
Number of shifts per working day	
Total number of employees	
Total annual cost of production	
Total annual cost of energy	

2. ENERGY DATA

2.1 Monthly Summary of Fuel Oil Consumption and Costs (2015 & 2016)

Month	Consumption (tons)		Costs of consumed fuel (USD)	
	2015	*2016*	*2015*	*2016*
January				
February				
March				
April				
May				
June				
July				
August				
September				
October				
November				
December				

2.2 Monthly Summary of Natural Gas Consumption and Costs (2015 & 2016)

Month	Consumption (m^3)		Costs of consumed fuel (USD)	
	2015	*2016*	*2015*	*2016*
January				
February				
March				
April				
May				
June				
July				
August				
September				
October				
November				
December				

2.3 Monthly Summary of (*other type of fuel*) Consumption and Costs (2015 & 2016)

Month	Consumption (m^3)		Costs of consumed fuel (USD)	
	2015	***2016***	***2015***	***2016***
January				
February				
March				
April				
May				
June				
July				
August				
September				
October				
November				
December				

2.4 Monthly Summary of Electricity and Costs (2015 & 2016)

Month	Consumption (kWh)		Costs of consumed fuel (USD)	
	2015	***2016***	***2015***	***2016***
January				
February				
March				
April				
May				
June				
July				
August				
September				
October				
November				
December				

Tariff description:

3. PROCESSES

Overall process description

Major energy consuming processes
Please give emphasis only to processes with high energy consumption.

4. BOILER OPERATIONS

Number of Boilers	
Total capacity	
Total annual production of heat energy (MJ/yr)	
Total annual fuel consumption	
Total annual operating time (h/yr)	
Total annual quantities of water supplied to the system	

Draft scheme of the boiler room
Please provide a draft scheme of the boiler room.

4.1 STEAM BOILER

Type of boiler	
Design capacity (t/h)	
Fuel	
Total annual operating time (h/yr)	
Age (years)	
Rated capacity (t/h)	
Annual fuel consumption (yr)	
Annual operating period	

Pressures and Temperatures

Steam pressure at boiler outlet (kPa)	
Steam temperature at boiler outlet (°C)	
Water temperature at boiler inlet (°C)	
Combustion air temperature (°C)	
Temperature of gas leaving the boiler (°C)	
Fuel temperature (°C)	

Flue Gas Analyses

CO_2	
O_2	
CO	
N_2	
Excess air	

5. STEAM DISTRIBUTION

System description
Please describe the steam distribution system.

Metering
In case there are meters at the end-users in the factory, please describe them.

Condensate return
In case there is condensate return, please provide a short description of the system.

6. COMPRESSED AIR SYSTEM

Number of compressors	
Total capacity	
Capacity per unit	
Output pressure (kPa)	
Total capacity of electric motors (KW)	
Capacity of each electric motor	
Volume of the tank	

Parameters

Working pressure of machinery (kPa)	
Entering air temperature (°C)	
Daily operating time (compressors)	

7. OTHER INFORMATION

Layout of the factory
Please provide, if it is possible, a layout of the factory.

Process flowchart
Please provide simplified process flowchart.

Energy audit
Have you ever conducted an energy audit before? If yes when?

Energy efficiency measures
Did you implement any energy efficiency measures in the last two years? If yes please describe them.

Certification
Does the factory receive any certification (e.g. ISO 9001 etc.)?

Energy management
Is there an energy management department?

Utility bills
Please provide us with the utility bills for the last year (2016).
Other Information
Please mention any other issues that you believe are important.