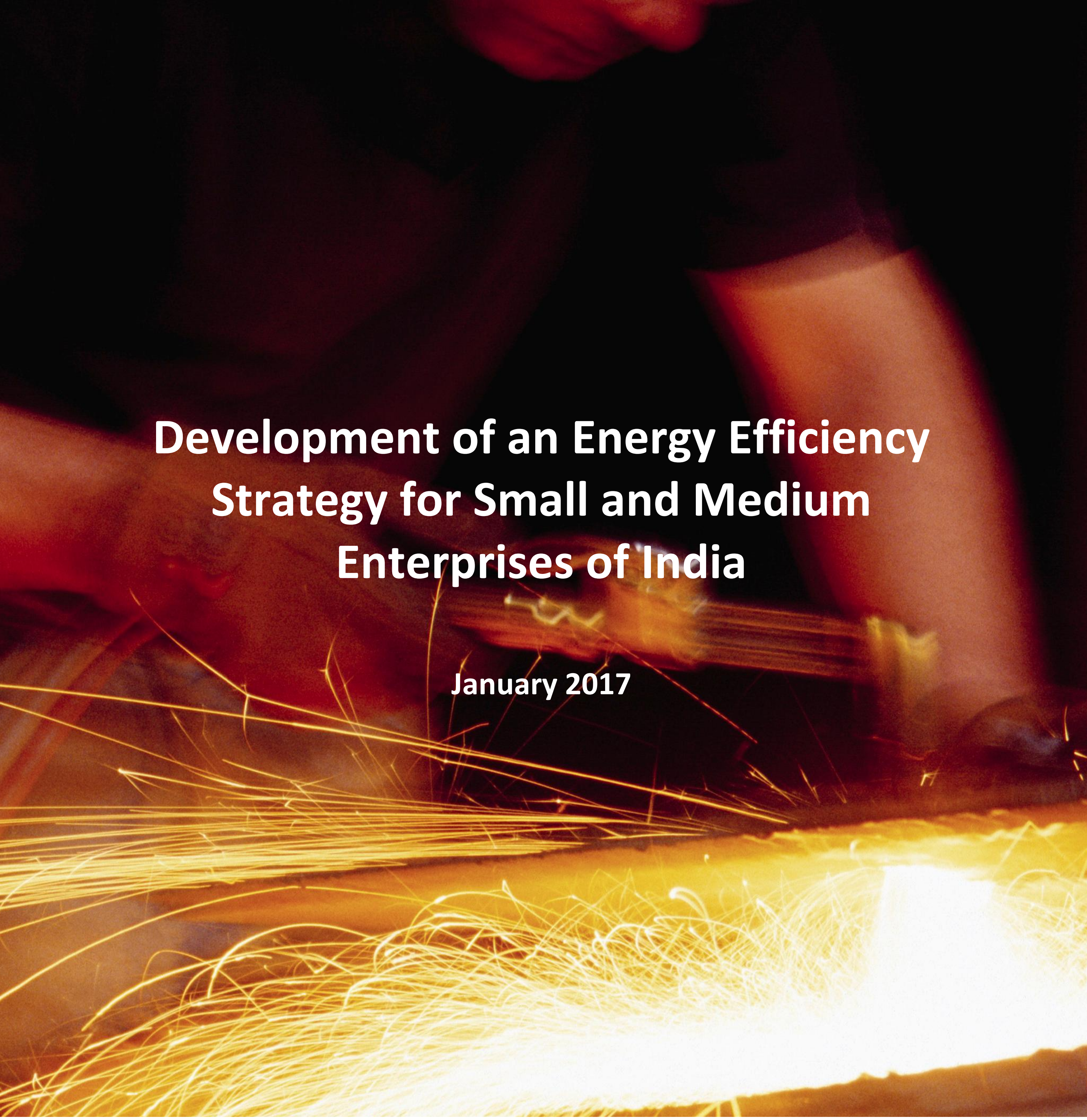

Development of an Energy Efficiency Strategy for Small and Medium Enterprises of India

January 2017

An initiative supported by

SHAKTI SUSTAINABLE ENERGY FOUNDATION

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Shakti Sustainable Energy Foundation works to strengthen the energy security of India by aiding the design and implementation of policies that support renewable energy, energy efficiency and the adoption of sustainable transport solutions.

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Contents

Abbreviations

BEE	Bureau of Energy Efficiency
CBA	Cost Benefit Analysis
CII	Confederation of Indian Industry
EE	Energy Efficiency
GEF	Global Environmental Facility
IRR	Internal Rate of Return
MCA	Multi Criteria Analysis
MoMSME	Ministry of Micro Small and Medium Enterprises
MSME	Micro Small and Medium Enterprises
SIDBI	Small Industries Development Bank of India
SSC	Scheme Steering Committee
TEQUP	Technology and Quality Upgradation Support
TERI	The Energy and Resources Institute
UNIDO	United Nations Industrial Development Organization
VFD	Variable Frequency Drive

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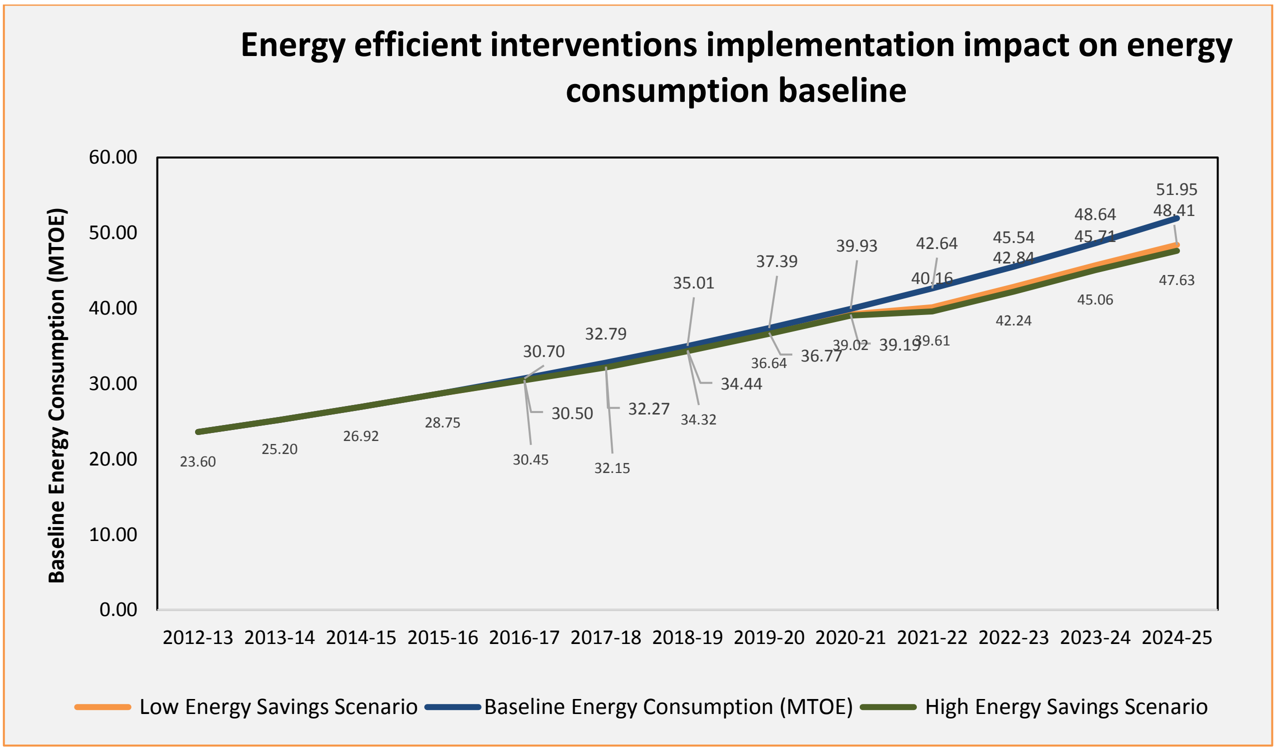
1 Executive Summary

The project for Developing an Energy Efficiency Strategy - Vision 2025 for the SME sector was conceptualized to support in developing an enabling environment to expand and accelerate the adoption of energy efficiency initiatives across the sector.

During discussions with the stakeholders in the selected clusters (Faridabad, Varanasi, Ludhiana and Ankleshwar), it was found that the MSME units faced a number of challenges w.r.t. adoption of energy efficient technologies. Some of the major challenges faced by the unit owners were:

- Limited knowledge about the energy efficient technologies
- Lack of awareness about suppliers and purchase of energy efficient equipment
- Unavailability of financial strength to implement the energy efficient technologies
- Lack of knowledge about the process to avail financing through MSME schemes
- Limited knowledge and time to perform techno-financial analysis about the equipment
- Limited replication of EE technology and sharing of best practices
- Untrained workers and technicians

Keeping in mind the barriers and challenges, a list of energy efficiency technologies were selected and energy savings due to these interventions was plotted against the baseline energy consumption by the MSME sector. It was observed that energy consumption can be reduced by 20-30% by adopting these technologies across all clusters. Figure below shows the reduction in energy consumption under one of the scenario discussed in this report.



The proposed interventions were prioritized on the basis of different financial, economic, environmental and social criteria using Cost Benefit Analysis and Multi Criteria Analysis. A excel based user friendly Decision Support Tool has been developed in which the user can define the values for certain parameters like replication potential of the technology, achievable energy savings, cost of electricity, maturity of technology, ease of implementation etc. The prioritization of the proposed EE technologies in the scenario discussed in the report is as given in the table below.

Interventions	Implementation Year
VFD installation for motors	2016-17
Insulation Improvement	2017-18
Efficient pumping system	2018-19
Rewinding of motors	2019-20
New boiler installation	2020-21
Fuel Switch	2021-22
Lighting – LEDs Installation	2022-23
Compressors	2023-24
Waste heat recovery	2024-25

This implies that VFD installation in motors is the best intervention compared to the other energy efficient technology options w.r.t. the criteria of evaluation (i.e. cost of implementation, payback, energy savings, emission reduction, ease of implementation etc.). The prioritization of interventions will vary as per the user inputs in the Decision Support Tool.

After understanding the on-ground challenges and the impact of energy efficient technologies on the MSME sector, a list of recommendations were proposed under this project. These recommendations can support the MSME units with respect to easy access to energy efficient equipment, skilled manpower and empowered cluster associations. The challenge, solution, activities to be performed and the outcome with respect to each recommendation has been described in brief.

2 Project Background and Methodology

The objective of the project is to support in designing an Energy Efficiency Strategy - Vision 2025 by analysing energy efficiency technologies and proposing enabling policy, strategy, regulatory and institutional measures to increase their penetration in the MSME sector. The Energy Efficiency Strategy Vision, is intended to provide key stakeholders adequate clarity on available energy efficiency technological options and their impact on MSME sector in short to medium term (2015-2025), apart from assessment of existing and forthcoming challenges in energy scenario.

The step by step methodology followed to prepare a comprehensive Energy Efficiency Strategy for the Indian MSME sector is discussed in brief in this chapter.

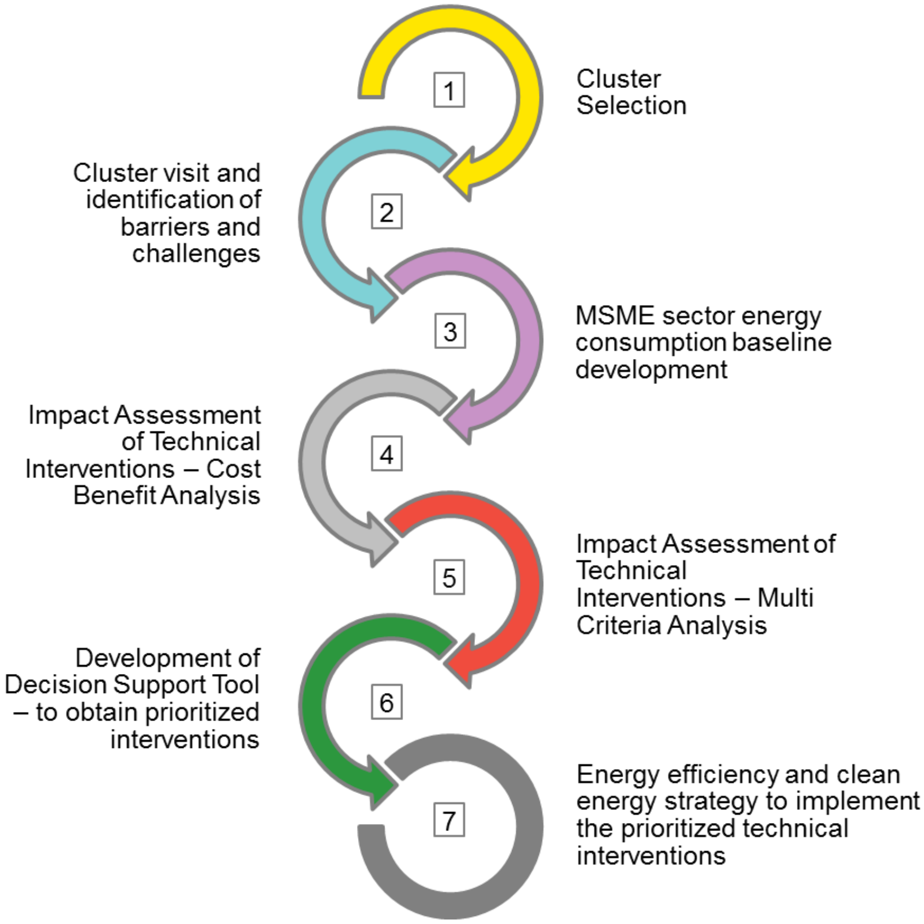


Figure 1: Approach followed to prepare Energy Efficiency Strategy

A description of each of the steps can be found in the subsequent chapters.

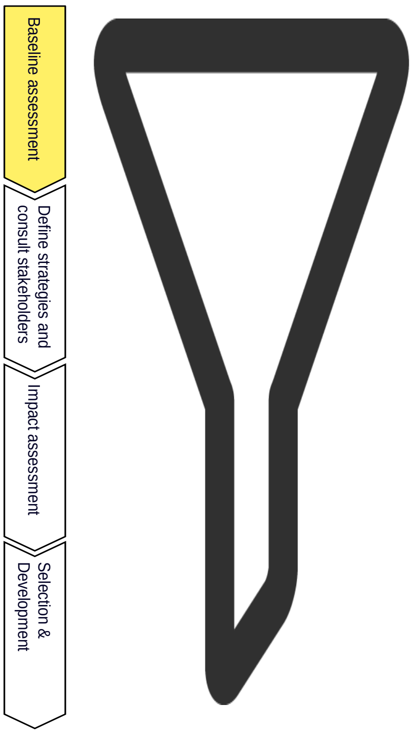
2.1 Cluster Selection

To select suitable clusters, an initial exercise was done to collect data regarding the location and size of the cluster, the type of products and sub-products produced, the total energy consumption, the electrical and thermal energy consumed and the specific energy consumption of the cluster. All this data was collected through secondary research and literature review.

One of the most important steps in this project is the selection of clusters that would be further analysed with regards to implementation of energy efficiency technology interventions.

This analysis would lead to policy level recommendations for the energy efficiency strategy to be developed for the SME sector.

The selected clusters should have high energy consumption, higher number of units for greater replication potential and should cover different industrial sectors. The criteria for selection of these clusters are given in brief in the figure below.



Level 1 screening

Selection criteria 1: Energy consumption
- Annual energy consumption of the cluster
- Energy intensity and specific energy consumption

Level 2 screening

Selection criteria 2: Suggestions of MoMSME
- Clusters critical to MoMSME in terms of increasing energy consumption will be reviewed.

Selection criteria 3: Clusters selected for large scale EE programs
- In last decade agencies like GEF, The World Bank, EU, SDC, UNDP, UNIDO, AFD, SIDBI and BEE supported implementation of large scale energy efficiency programs in SME clusters. Those clusters will be reviewed.

Level 3 screening

Selection criteria 4: Consultation between EY and SSEF
- Based on internal analysis the long list of clusters will be prepared (like level of involvement of entrepreneur).
- EY and SSEF to jointly shortlist 4 – 5 energy intensive clusters from the list

Figure 2: Cluster Selection Criteria

2.1.1 Selection Criteria 1: Energy Consumption

Under this selection criterion, the clusters were selected on the basis of their annual energy consumption and specific energy consumption. Under the annual energy consumption, both the thermal energy and the electrical energy data were collected wherever available. A list of MSME clusters with high total energy consumption and specific energy consumption was prepared using data from various cluster manuals, profiles and DPRs already available.

Some of the highest energy consuming clusters in India shortlisted under this criterion were Odisha sponge iron cluster, Surat textile cluster, Morbi ceramic cluster, Tirupur textile cluster, Faridabad mixed cluster, Ankleshwar chemical cluster, Ahmedabad chemical cluster, Kolhapur foundry cluster, Vellore rice mill cluster, Muzaffarnagar paper cluster and Varanasi brick cluster among others.

2.1.2 Selection criteria 2: Suggestions of MoMSME

Under the scheme on Technology and Quality Upgradation Support to MSMEs (TEQUP), the Ministry of MSME had set up a Scheme Steering Committee (SSC) under the chairmanship of the Additional Secretary & Development Commissioner (MSME) which acted as the apex decision making body for the Scheme.[1]

Further, this committee was also responsible for exploring ways of aligning the activities of BEE with those of MoMSME in the XII plan under BEE SME scheme. Additional Secretary & Development Commissioner (MSME) suggested BEE to target the following clusters:

- Food (Indore, Madhya Pradesh)
- Seafood (Kochi, Kerala)
- Forging (Ludhiana, Punjab)
- Brick (Varanasi, U.P.)
- Textile (Pali, Rajasthan)

Also, the MSME Development Institute was asked to support BEE in its SME initiatives and BEE was asked to promote the TEQUP scheme in its workshops.[2]

2.1.3 Selection criteria 3: Clusters selected for large scale EE programs

The third criterion for selecting clusters was based on the information available for the cluster through secondary research so that a complete and comprehensive review can be performed. A number of large scale energy efficiency projects have been undertaken in the MSME sector in this regard. Some of the major projects with the clusters covered within the project are listed below:

i. UNIDO–GEF project on promoting energy efficiency and renewable energy in selected MSME clusters in India

ii. BEE SME Program

iii. GEF-World Bank-BEE project on Financing Energy Efficiency at MSME

iv. Benchmarking and mapping energy consumption in MSME Sector

v. MSME Financing and Development Project

vi. The TEQUP scheme for improving the competitiveness of the MSME Sector

2.1.4 Selection criteria 4: Consultation with the client

The fourth criterion for selecting clusters was based on the consultation between the consultant and Shakti Sustainable Energy Foundation (SSEF) regarding any specific preference of the client. The information collected under each of the criteria was reviewed with SSEF and the following four clusters given in table below were selected for detailed

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[1] Source: Technology and Quality Upgradation Support to Micro, Small and Medium Enterprises, MoMSME http://msme.gov.in/WriteReadData/DocumentFile/technology&quality10.pdf

[2] Energy Efficiency Program for Small and Medium Enterprises (SMEs), Bureau of Energy Efficiency, http://sameeeksha.org/pdf/presentation/BEE-SME-Prog-An%20update.pdf

review under this project. Brief reasons for selecting these clusters are also listed in the table.

Table 1: List of Selected Clusters

Selected Cluster	Reason for Selection
Faridabad Mixed Cluster	▶ Already part of a number of programs and projects related to energy efficiency like GEF-World Bank-BEE project on Financing Energy Efficiency at MSME ▶ Large cluster with 12000+ units, therefore high replication potential ▶ Already implemented few energy efficiency interventions which will help in preparing a robust policy document. ▶ Since Faridabad is a mixed cluster with almost 15 different sector products, policy interventions suggested for this cluster would be applicable to many other clusters.
Varanasi Brick Cluster	▶ Suggested by the MoMSME to BEE for identification of energy efficient interventions ▶ Already part of a number of programs and projects related to energy efficiency like BEE SME Program, UNDP-GEF project on Energy Efficiency Improvements in India Brick Industry ▶ Establishment of Testing Laboratory by Cluster Association
Ankleshwar Chemicals Cluster	▶ Secondary data available. ▶ High replication potential with 726 units ▶ Already part of a number of programs and projects related to energy efficiency like GEF-World Bank-BEE project on Financing Energy Efficiency at MSME
Ludhiana Knitwear Cluster	▶ Large cluster with around 14000 units, therefore very high replication potential ▶ Already part of a number of programs and projects related to energy efficiency like BEE SME Program and MSME Financing and Development Project

2.2 Cluster visits and identification of barriers and challenges

The second step of the project involved visiting all the selected clusters to understand the proliferation of knowledge regarding energy efficiency and adoption of energy efficiency interventions. As most of the clusters were already covered under one or the other large energy efficiency program, stakeholder consultations were organised with the MSME unit owners and the respective cluster associations to understand the impact of energy efficiency programs performed in their cluster units. The on-ground implementation challenges and the barriers to carrying out the suggested interventions was discussed in detail. The unit owners and cluster associations were also interviewed regarding the kind of policy and regulatory support required from the government to achieve the desired outputs.

2.3 Development of MSME Sector Energy Consumption Baseline

Cluster visits in each of the clusters was followed by creation of the MSME sector energy consumption baseline to understand the amount of electrical and thermal energy consumed by the units in the business as usual situation. The base year was selected as 2012-13 and the future year as 2024-25.

The baseline study was important to calculate the reduction in energy consumption by implementing energy efficiency technology interventions in the MSME sector. The interventions selected for this project are as listed below:

1. Waste Heat Recovery
2. Optimization of boiler and steam system
3. Efficient rewinding of motors
4. Fuel switch
5. Energy Efficient lighting
6. Efficient pumping systems
7. Improvement of insulation
8. Use of VFDs for motor control
9. Efficient compressors

2.4 Development of Decision Support Tool (DST)

After selecting the energy efficient interventions, the next step entailed building a Decision Support Tool for assessing the impact of implementing these technologies on the MSME sector. DST is developed as an excel spreadsheet based tool where the technologies were assessed on a set of common financial, environmental, economic and social criteria. Two different analysis namely the Cost Benefit Analysis (CBA) and the Multi-Criteria Analysis (MCA) were part of this tool. The output of the DST was a prioritised list of interventions that can be implemented in the sector. Also, policy, strategy, regulatory and institutional measures were recommended for each of the interventions.

2.4.1 Cost Benefit Analysis

In CBA the cost of implementation and the fuel/energy saved (benefit) from each intervention was calculated. Both the costs and benefits were monetized for each intervention. The calculations were done in line with the baseline energy consumption for the years 2012-13 to 2024-25.

This analysis formed the first step of evaluating the different interventions and aided in understanding the benefits versus the cost involved. The results of this financial analysis were used in the Decision Support Tool to prioritize the selected interventions.

2.4.2 Multi Criteria Analysis (MCA)

As the name suggests, MCA was performed to score the interventions on a set of different financial, environmental, economic and social criteria. The criteria were assigned a weight as per their relative importance. Each of the interventions was scored on the different criteria to calculate a final score for each intervention and thus prioritise them on the basis of the selected criteria.

The criteria selected in the MCA are as listed below:

1. Cost of Implementation of the intervention
2. Emission reduction
3. Ease of implementation of the intervention
4. Fuel Savings
5. Maturity of technology proposed
6. IRR and payback period
7. Cost of operational maintenance

2.5 Development of an Energy Efficiency Strategy

The last part of the exercise involved developing a strategy for successful implementation of all the interventions proposed.

After getting the prioritized list of interventions from the Decision Support Tool, the user is able to view the recommended policy, strategy, regulatory or institutional measures required to be undertaken by the responsible government department / cluster association to ensure a smooth shift from a proposed idea to a successfully implemented technology on the ground.

3 MSME Sector Energy Consumption Baseline

The MSME sector in India accounts for 45% of the manufacturing output and 40% of exports. The sector consumes about 25% of the total energy consumed by the industrial sector.[3] As per the Annual Report 2015-16 published by the MoMSME, the total number of working enterprises (both registered and unregistered) in the MSME sector adds up to 361.76 lakhs. Since the number of units in the sector is very high in comparison to the amount of energy consumed by the sector, plotting an energy consumption baseline becomes significant in assessing the impact of energy efficiency technology interventions proposed for the sector.

The first step in developing an energy efficiency strategy for SMEs is to assess the energy consumption in the MSME sector. It is important to develop the energy consumption baseline so that the energy savings due to interventions are easily measured against the baseline consumption, clearly indicating the reduction in consumption due to adoption of certain energy efficient processes/equipment. In order to measure the future performance on energy management, the starting point is setting a baseline using the information on past energy consumption over a suitable time period.

As per the Report of The Working Group on Power for Twelfth Plan (2012-17) published by the Government of India in 2012, the energy consumption by the SME sector has been forecasted based on the replication of results and findings from the 11th Plan which includes

- Implementation of recommendations on energy efficient technologies in DPRs (Detailed Project Reports).
- Development of local technologies service providers for SMEs,
- Capacity building of stakeholders including bankers /FIs and strategic approach for dissemination of results
- Move from cluster based approach to sector based approach to enable large degree implementation in the sectors selected under the 11th Five Year Plan.[4]

The details of projected energy consumption trend (electrical and thermal) in energy intensive SMEs as published in the Report of the Working Group on Power for Twelfth Plan by the GoI is given below:

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[3] Annual Report 2015-16, Ministry of Micro, Small and Medium Enterprises, Government of India http://msme.gov.in/WriteReadData/DocumentFile/MEME%20ANNUAL%20REPORT%202015-16%20ENG.pdf

[4] Report of The Working Group on Power for Twelfth Plan (2012-17), Ministry of Power, Government of India, January 2012, http://planningcommission.nic.in/aboutus/committee/wrkgrp12/wg_power1904.pdf

Table 2: MSME Energy Consumption Baseline from 2012-13 to 2019-20 as projected by GoI

	2012-13	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19	2019-20
Electrical Energy Consumption, BU	41.2	44	47	50.1	53.5	57.2	61.1	65.2
Electrical Energy Consumption, Million toe	3.54	3.78	4.04	4.31	4.60	4.92	5.25	5.61
Thermal Energy Consumption, Million toe	20.06	21.42	22.88	24.44	26.10	27.87	29.76	31.78

Since the scope of the project involves recommending an energy efficiency strategy for the SME sector till 2025, the energy consumption baseline is also extended up to the same year for consistent results.

It was observed that the year-on-year growth in energy consumption of both electrical and thermal energy from 2012-13 to 2019-20 was taken as 6.8%. The same annual growth rate has been assumed to project energy consumption up to 2024-25. The revised energy baseline till 2024-25 is as given in the table and figure below:

Table 3: MSME Energy Consumption Baseline from 2012-13 to 2024-25

(in million toe)	2012-13	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22	2022-23	2023-24	2024-25
Electrical Energy Consumption	3.54	3.78	4.04	4.31	4.60	4.92	5.25	5.61	5.99	6.39	6.83	7.29	7.79
Thermal Energy Consumption	20.06	21.42	22.88	24.44	26.1	27.87	29.76	31.78	33.94	36.25	38.71	41.35	44.16
Total Energy Consumption	23.60	25.20	26.92	28.75	30.70	32.79	35.01	37.39	39.93	42.64	45.54	48.64	51.95

As it can be observed from the baseline data, the projected energy consumption shows a steep increase (by more than 100%) from 23.60 million toe in 2012-13 to 51.95 million toe in 2024-25. This implies a sheer growth in the SME sector in the future years which all the more emphasizes on the application of energy efficiency technologies and practices in the SME sector to reduce its energy footprint and increase energy security.

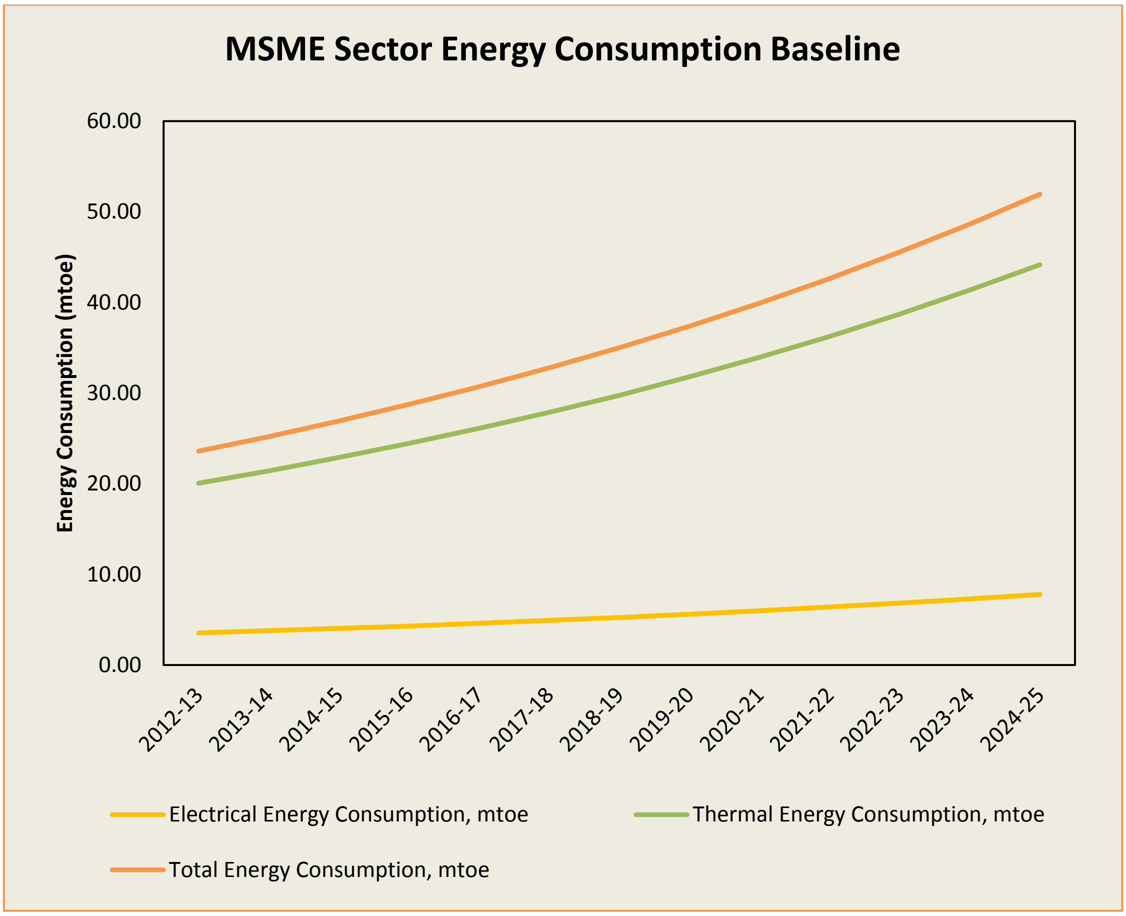

Figure 3: SME sector Energy Consumption Baseline Graph

Figure above shows the baseline energy consumption of the SME sector shown in the graphical form. The impact of different technical interventions selected in the subsequent chapters will be plotted against the baseline to assess the impact of the interventions on the total baseline energy consumption as a whole.

4 Challenges and Recommendations in implementing Energy Efficient Technologies

To understand the challenges faced by the SME units in implementing energy efficiency technologies, stakeholder consultations were organised in all the four clusters selected for this project. The consultative meetings were organised within the cluster with the Cluster Associations and unit owners. The main objective of these meetings was to recognize the level of understanding in the cluster regarding energy efficiency. Discussions were held with the stakeholders around the barriers and challenges faced by them, support available and required from the cluster associations, government and financial institutions, knowledge about the energy efficient interventions that can be implemented, feedback about the previous energy efficiency projects executed in the cluster etc.

The challenges faced by the SME units and the cluster associations and some suitable recommendations are listed below in the sections that follow.

4.1 Faridabad Mixed Cluster

The consultative meeting was organised with the IamSMEofIndia, the SME Cluster Association located in Faridabad. The meeting was also attended by officials from SIDBI and almost 25-30 unit owners. Some of these units had already had energy audits as part of previous programs and had installed some energy efficient technologies. The feedback regarding the energy efficient technologies – barriers, challenges, reduction in energy consumption was also discussed.

Challenges

- Units where energy audits have already taken place are well aware of the energy efficient technology interventions that can be implemented. However, transparent flow of information is a challenge as success stories of implementation of energy efficient techniques are not being shared with other units.

- Though the units are aware of purchasing energy efficient equipment, the purchase orders raised do not always specify the purchase of energy efficient equipment or equipment with higher energy star rating.

- Techno-financial analysis before purchasing an energy efficient equipment is one of the main challenges faced by the MSME unit owners. A repository of all the energy efficient equipment suppliers can be maintained by the Cluster Association to support the units in getting quick service at a good price.

- Though the workshops organised for the unit owners and staff are useful, they are sometimes repetitive for participants who’ve attended multiple workshops. For a mixed cluster like Faridabad with numerous industries segments, industry and technology specific workshops can be organised.

- One of the major factors for reduced implementation of identified energy efficiency interventions was lack of innovative findings.

- For previous EE programs, sometimes the expert conducting the energy audits were not experts of the relevant industry.

- For previous EE schemes, release of subsidy from SIDBI took a considerable time. Also, the documentation for implementation of energy efficiency measures was bulky and difficult to understand for some unit owners.

Recommendations

- While designing future energy efficiency programmes and schemes in the MSME clusters, role of cluster association should be enhanced as they are one of the agencies that remain with the unit owners till the end of cycle and beyond

- For new energy efficiency programs, industry associations may be designated to monitor implementation and compliance process for all the units audited in a cluster

- A repository of best practices to enhance energy efficiency in the MSME units can be maintained in the public domain. The cluster associations should promote the use of this repository so that existing/new member can adopt these practices from the beginning.

- To promote adoption of energy efficiency, a technology based suggestion can be introduction of a mobile based application. This application will provide the unit owners with the list of EE equipment suppliers available in their cluster.

- A store house should be established & maintained by Government/cluster associations which maintains inventory of high turnover items in a cluster. Say, if energy efficient motors, LEDs, etc. are sold at the store then most of the units would prefer to procure the motors and other equipment directly from the store. This will enable them to evade lot of techno-financial hassle plus save a lot of time which is critical in case of equipment/system breakdowns.

- During future energy efficiency programs for conducing energy audits in the units, it would be better to rope in process experts along with energy auditors. So, that both process and utility related energy efficiency levers are identified.

4.2 Ankleshwar Chemicals Cluster

The stakeholder consultation organised in Ankleshwar cluster included members of the Cluster Association and unit owners. Some of the major points of observations are listed below:

Challenges

- Information on existing EE equipment suppliers were not available to units.

- During previous energy efficiency programs, modalities and procedure for seeking external funding for implementing EE measures was not detailed out.

- There is no existing central agency that ensures appropriate information flow, project management and efficient coordination for EE interventions with host of stakeholders.

- While implementing previous energy efficiency programs, energy audit project duration was too short to implement the agreed activities in large number of units. Though some units found EE interventions as sustainable in nature & highly rewarding in terms of revenue, others observed interventions as futile exercise generating no savings.

- Capacity Building Workshops organised in the past were monotonous and not very participatory in nature. Further, the workshop training material was also not accessible to the participants.

- In the past, the unit owners received limited support from the cluster associations for implementing EE measures.

- During previous energy efficiency programs, low awareness on prevalent financial schemes for implementing EE interventions

- During past energy audits under various programs, no technical discussions were done on the project reports for building the unit's understanding on recommended EE interventions.

Recommendations

- Before designing EE programs in the future, a consultative approach should be undertaken by organizing brainstorming sessions to unearth innovative ideas in the cluster.

- A central agency at the cluster level can be formulated for maintaining better coordination, tracking cluster level progress and resolving differences. For instance, during past EE programs, implementing agency could not access the vendor list as it was supposed to be prepared by another organization. Such lack of coordination led to substantial delay and loss of interest.

- Role of cluster association should be enhanced to support the unit owners in adopting new EE technologies and attaining finance for the same.

- Workshops need to be streamlined according to the needs of industrialists to ensure better participation and adoption of interventions.

- Not only the technology provider details should be made available (local + national mix) but also the services of supplier should be looked into.

- The timeframe allocated against each activity of the project was pretty steep. The window margin need to be looked into and logically enhanced.

- Training material should be made more cluster specific and not very generic version of best practices since the concerns of units and challenges are cluster specific.

- Clarity and timely intimation about schemes like PLG should be provided to avoid unwanted effort at both ends – unit & SIDBI.

- Financial due diligence of participating units should be undertaken and only the interested candidates should be pursued to ensure better success ratio and concentration of resources

4.3 Varanasi Brick Cluster

Meetings were held with members of Int Nirmata Parishad, the Varanasi Brick Cluster Association and brick kiln owners to understand the challenges faced by them at the ground level.

Challenges

- One of the major challenges faced by the units is the availability of good quality high calorific value coal. As the main fuel for the brick kiln, high GCV coal is not easily available to the brick manufacturers. In some cases, coal is sourced from other countries to improve the quality of bricks produced.

- Further, in last three years, the cost of coal has increased substantially. Government has increased the tax on coal multiple times which is affecting the profitability and viability of the business.

- The kiln owners believe that financial institutions don't trust them w.r.t. disbursement of funds as brick production is still considered a shifting industry.

- Many brick units face difficulty in availing loans from financial institutions as there is no proper maintenance of book of accounts, and other documents required to avail the loan.

- Most of the kilns are built on leased land with unregistered agreements. Therefore, getting loans becomes a challenge.

- History of loan repayment has been poor in the past which discourages banking institutions in providing loans.

- One of the major energy efficient technology, i.e. Zig Zag firing kilns has been implemented in almost 100 kilns in Varanasi cluster. However, there is no incentive scheme available to units who want to install the energy efficient technology.

- Presently, most of the kilns are not mechanised. The cost of mechanization of one kiln is of the order of 20-25 crores which is not available with the unit owners.

- Retention of labour is a big challenge in the brick industry. Therefore, the unit owners retain their labour for the whole year despite the kiln operation limited to 6-7 months.

- Due to limited funds, green bricks are dried in the open only. This involves high risk of damage from unpredicted rainfall.

- Though the cluster association keeps planning an array of training programs for different stakeholders of the cluster, the brick industry still lags behind by more than 100 years w.r.t. other international counterparts.

- Fly ash bricks, a recommended substitute to the clay bricks produced in the cluster are capturing the market rapidly.

- No nearby government lab has testing facilities for testing of coal, clay and final bricks produced in the cluster. Each of these test costs between INR 2-8 lakhs.

- Clay is one of the main raw materials required in brick production. GOI has allowed clay excavation in India up to only two meters against the European norm of excavation of up to 30 meters.

Recommendations

- International experts from other developed countries should be invited for sharing best practices and for knowledge dissemination on ways to improve the brick production and fuel efficiency.

- Knowledge of advanced machinery used abroad (EU, China) should be easily available to the unit owners through organizing workshops, visits to other units, symposium with equipment manufacturers etc.

- Tunnel kiln technology that utilizes the waste heat generated in the kiln for drying bricks can be implemented in India on a pilot basis. Subsidy or fiscal incentives may be provided by the government to support such an initiative as the unit owners lack in both experience and capital.

- Trainings should be conducted on proper maintenance of financial accounts and its importance and the set of documents required for availing loans from financial institutions.

- Technology import should be promoted in the sector from developed nations for implementing a pilot project in each of the clusters to support technology improvement and reduction in fuel consumption and emissions.

4.4 Ludhiana Knitwear Cluster

Stakeholder consultation was organized with Ludhiana Cluster Association – Knitwear Club and its members to understand the challenges faced by them at the ground level.

Challenges

- MSMEs feel that their project loan proposals get rejected by banks due to non-submission of requisite collateral/guarantee. Further they believe that the loan procedural cycle is very long, document requirement is very stringent etc.

- Stability of manpower is a big problem in the cluster. Skilled manpower is hard to retain as they are poached by other units.

- There are about 70 industry association in the cluster, but very few are actively taking part in development activities. Most of the associations are busy with operational challenges and have limited bandwidth to invest in developmental activities.

- Awareness about intellectual properties like copyrights, patents, trademarks, designs etc. is very low in the cluster.

- Shortage of power during summer is a serious concern as most of the small-scale units, dyeing units, garment units and furnace units don't have equivalent capacity generators to run their units. Even for those who have, power cuts also increase the cost of production and high rejection.

- Low penetration of energy efficiency technologies – even the basic like efficient lighting or solar solutions due to limited government support and unawareness. Units have also not been too proactive as the business (sale of woollens) has been low for last 2 to 3 years because of mild winter.

- The industry has been facing tough competition from countries like China, Bangladesh, Sri Lanka etc. These products are cheaper and have been entering the markets in large volumes.

- Due to increasing competition at national and international level, heavy import duty, fluctuation in raw material prices etc., cluster entrepreneurs have been witnessing declining profit margins.

- Quality of machines and adoption of new technologies has remained a challenge.

- Inventory management: The current system of order booking and production synchronisation gives serious problem of piling up of huge inventories in the industry. There is a need to look for innovative ways for such inventory and order management.

- Most firms in the cluster are satisfied with their way of doing business and are negligent towards the market demands. System implementation is poor and very few firms have taken compliance certification.

- There is lack of innovation in domestic market too as manufacturers specializing in the domestic market sell through agents, wholesalers, retailers and end-product users.

- Most of the units in the cluster work in a less professional manner with no or very less standardized practices. Business improvement techniques like lean, six-sigma, TQM are missing in the cluster. Compliance certification is taken only on the behest of customers.

Recommendations

- Trade fair /Exhibition ground should be developed near the city which would be easily accessible & have requisite infrastructure. The makeshift arrangement that exists is not functioning properly. This will help in getting global players and experts to Ludhiana much on lines of Gongzuo, China. Exposure to a wider market will not only increase sales, it will also increase awareness about best practices used in the industry to save energy. Higher sales will equip the unit owners with enough financial means to invest in energy efficiency equipment.

- The cluster is still very conventional in its method and usage of Information & Communication Technology (ICT) which is restricted to some large units for Accounts/

Inventory Control / Designing /Office Communication / Reports, etc. The units are aware that better availability of CAD/CAM/SAP/ERP facilities in the Apparel and Knitwear Cluster Ludhiana is important. Therefore, some financial mechanism should be put in place for setting up ICT to achieve a better efficiency and accuracy in the work processes and end products.

- To increase the knowledge of energy efficiency at the ground level, a better training and bridging mechanism should be put into practice where the skilled and trained operators get absorbed in the industry easily.

- Considering the size and importance of Ludhiana cluster, techniques like six sigma, professional certifications, endorsements, etc. will be helpful to reduce mistakes and achieve efficiency in the processes. In some cases, it can also lead to reduction in energy consumption.

- Manufacturers need to explore opportunities in yarn diversification, product diversification, product finish, etc. Introduction of E-marketing services can help domestic manufacturers gain knowledge about new ways to market their products. New ways to enable this knowledge transfer and awareness should be explored as higher sales will only provide manufacturers with the financial strength to upgrade their units' w.r.t. to use of energy efficient equipment.

4.5 Consultation with MSME sector Experts

Stakeholder consultations were conducted with several experts and organisations that have been working in the MSME sector like Bureau of Energy Efficiency (BEE), SIDBI, The World Bank, TERI, CII etc. All the feedback was with respect to the energy audits, workshops and training programs conducted by these organisations to promote energy conservation, energy efficiency technologies. The feedback collected is as follows:

- Some central level platform should be developed or existing platforms like SAMEEEKSHA to be strengthened where all stakeholders can interact. This will greatly streamline the coordination related activities and avoid lots of confusion.

- Branch office of a financial institution like SIDBI should always be located within or proximity to the cluster.

- It should be clear as to the size of projects that are being funded by the financial institution. In one of the clusters, the impression most of the units had after their interaction with bankers were that they are not keen on funding the small projects of 5 to 10 lakhs and only favour the major ones which led to poor response to the scheme.

- If some MSME units were catering to the requirements of a sector which was facing slowdown, it greatly impacted the energy efficient technology investment capacity since most of the MSME units were having low capacity utilization. Still some of the units saw it as an opportunity since 50% of the machinery was available for carrying out interventions.

- For implementing EE interventions identified during previous energy efficiency programs, it was envisaged to prepare a panel of minimum 4 to 5 vendors which would be made available to any unit wanting to implement the EE measures. The underlying idea was also to promote competitive bidding. However, the pool of vendors was very limited to a few technologies where only the local players were listed. Small project size and lack of demand aggregation were identified as the main reasons for not being able to attract major vendors.

- The results of some pilot studies (as part of previous EE schemes) instilled confidence in unit owners to adopt the new EE technology and commence its replication. For the replication to trigger, one important prerequisite was awareness/dissemination programme, which didn't go off well in the case of MSMEs. The results of the pilot were poorly promulgated amongst units and public interaction or discussion about the results was low.

- One of the other reasons for failure of dissemination programme was that the MSME units themselves were also not too interested in sharing the benefits with their rivals/competing units in the same field. The units were not sharing the technological benefits in their internal association meetings which would have nudged other units.

- For many of the financially capable MSMEs, capital was not a major concern if the energy efficient technology made business sense. For example, in Ankleswar cluster, 2 technologies were imported from Germany and installed by the MSME units.

5 Technical Interventions to increase Energy Efficiency in MSME sector

As listed in the previous chapter, a list of barriers and challenges faced by the units in implementing energy efficient technology interventions have been discussed. With a clear idea of the issues faced, a list of technical interventions has been selected that can be introduced in the SME sector to increase energy efficiency technology adoption. The interventions have been selected in a way such that each intervention might not be applicable to every industry but has a major impact on energy consumption of the sector.

Nine technical interventions that have been shortlisted for evaluation are given in the figure below.

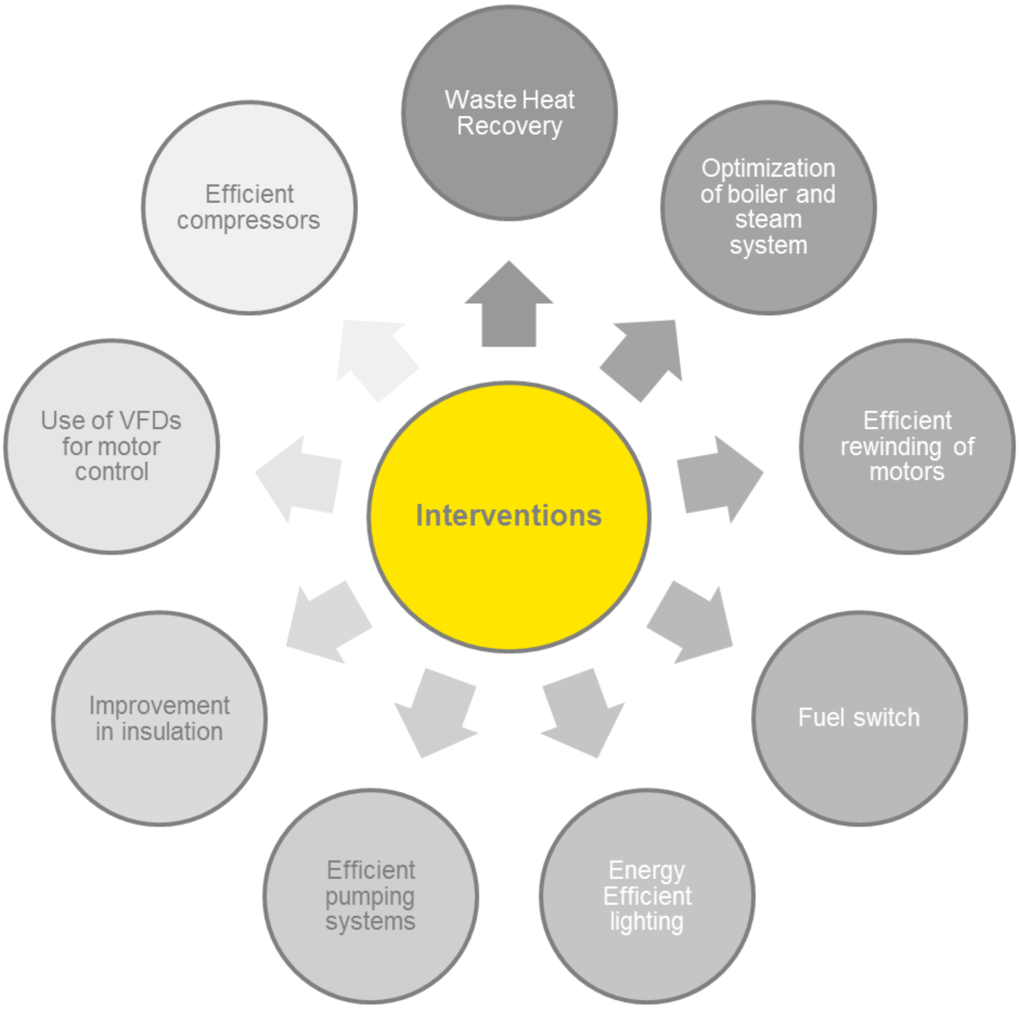

Figure 4: Selected Technical Interventions for SME Sector

Some of the interventions listed above help in saving electrical energy, while others help in reducing consumption of fuel and thus lead to reduction of thermal energy consumption. The reduction in energy consumption after implementing each technology has been calculated from 2012-13 to 2024-25 to estimate the effect of implementing the proposed interventions on the energy baseline for the SME sector.

Figure below shows the split of proposed interventions based on the energy saved by each one of them.

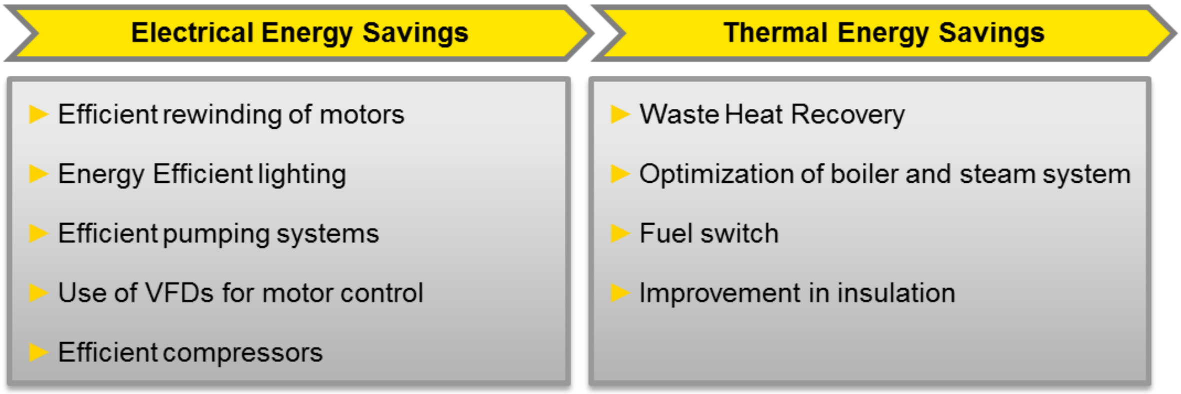

Figure 5: Type of energy saved by different interventions

In the subsequent sections of this chapter, each one of the interventions has been described and its cost and benefits have been calculated. Since conducting detailed energy audit was not part of the scope of this assignment, the cost of implementing the technology, energy consumption reduction, fuel saved and cost savings have been taken from reports available in public domain. The data taken from these reports have been scaled to the sectoral level based on assumptions regarding the replication potential of each technology. Further, since the on-ground situation in many units would be different than what is listed in the selected reports available online, it would be difficult to achieve the same level of energy savings by implementing the proposed EE interventions. Therefore, for the scenario calculations given in the sections below, the achievable savings for every technology has been taken as 70% of the savings calculated in the best-case scenarios given in the reports. For interventions where electrical energy savings are possible, per unit cost of electricity has been taken as INR 6.15/kWh.

In the Decision Support Tool, however, the replication potential, achievable energy savings and electricity cost have been kept as a user input to allow the users to choose a value they feel is suitable for each of the selected interventions.

The calculations shown in the subsequent sections have been done based on the following assumed replication potential and achievable savings given in table below.

Table 4: Assumed Replication Potential of selected Interventions

Interventions	**Replication Potential in SME sector (%)**	**Achievable Energy Savings (%)[5]**
Waste heat recovery	30%	70%
Insulation Improvement	30%	70%
Lighting - LEDs Installation	50%	70%
New boiler installation	30%	70%

[5] % of the savings calculated in the best-case scenarios given in the reports

VFD installation for motors	50%	70%
Efficient pumping system	40%	70%
Compressors	30%	70%
Rewinding of motors	40%	70%
Fuel Switch	30%	70%

The values for replication potential and achievable savings have been selected after consultation with sector experts, cluster associations, unit owners and in-houses analysis.

As per the study done by TERI, sub-sector wise energy consumption is as follows.[6]

Table 5: Sub-sector Energy Consumption

Sub sector	Total Energy Consumption (million toe)
Glass	0.2
Chemicals	0.3
Foundry	0.3
Dairy	1.3
Ceramics& Refractories	1.4
Textiles	2.3

Sub sector thermal energy consumption has been calculated from the total energy consumption by using a factor of 0.85. This factor has been derived on the basis of ratio between thermal energy consumption and total energy consumption as mentioned in the baseline for 2016-17 Thermal energy consumption below has been calculated by multiplying total energy consumption with 0.85 factor for the previously mentioned sub sectors. Objective behind this activity is to calculate the total thermal energy consumption occurring in the following equipment for the above mentioned sub sectors.

- Boiler
- Furnace

It is understood based on the secondary research that boiler has an application in the following sub sectors

- Chemical
- Dairy
- Textiles

[6] Benchmarking and Mapping energy consumption in Indian MSMEs, Study by AFD-ADEME-BEE-TERI, April 03, 2012, Page 14 - http://sameeeksha.org/pdf/Benchmarking_and_mapping_energy_consumption_in_Indian_MSMEs.pdf

Similarly, furnace has application in the following sub sectors:

- Glass
- Foundry, Ceramics and Refractories

Insulation is applied both to furnace and boiler. Therefore it finds an application in the following subsectors:

- Chemical
- Dairy
- Textiles
- Glass
- Foundry
- Ceramics and Refractories

A target thermal energy consumption has been calculated for the following interventions by adding the thermal energy consumption occurring in all the related sub sector for an intervention as explained above. Target thermal energy consumption mentioned is the total thermal energy consumption which could be targeted to calculate the energy savings from the concerned energy efficient interventions. Savings calculated with each of these interventions have been mentioned in the later sections of this report.

Table 6: Intervention wise Energy Consumption (Million toe)

Interventions	Target Thermal Energy consumption (Million toe)
Boiler	3.32
Furnace	1.62
Insulation	4.93
Waste Heat Recovery	4.93

Following enlists the assumptions considered while calculating the above mentioned thermal energy consumption.

1. The thermal energy consumption is 85% of the total energy consumption (same as the SME sector energy consumption baseline) in million toe.
2. 100% thermal energy consumption in the above sectors has been assumed to happen in either boiler or furnace.
3. Waste heat recovery and Insulation improvement intervention have been considered for implementation where either boiler or furnace is installed.

5.1 Waste Heat Recovery

Waste heat recovery aims to capture and reuse the lost or "waste heat" that is intrinsic to all industrial manufacturing. During the manufacturing processes, as much as 20 to 50% of the energy consumed is ultimately lost via waste heat contained in streams of hot exhaust gases and liquids, as well as through heat conduction, convection, and radiation from hot equipment surfaces and from heated product streams.[7]

Captured and reused waste heat is an emission free substitute for costly purchased fuels or electricity. Numerous technologies are available for transferring waste heat to a productive end use. For our analysis, we have considered the calculations from two different uses of these technologies:

1. Waste heat recovery by using de-super heater technology in refrigeration system for Gujarat Dairy Cluster[8]
2. Setting up waste heat recovery system in reheating furnace to recover waste heat from flue gases for Jamnagar Brass Cluster[9]

Assumptions:

- Average value of both the reports of thermal energy saving %, cost saving/energy saved and implementation cost/energy saved has been estimated from the available calculations.
- The technology can be replicated in 30% of the units across the MSME sector.
- The achievable energy savings have been taken as 70%.
- Cost of electricity is taken as Rs. 6.15/kWh.

The average energy saving percentage from the calculations is found to be 26%. This is multiplied by the targeted thermal energy consumption (in Million toe) by waste heat recovery systems (4.93Million toe), the replication potential of the technology across the SME sector (30%) and the on-ground achievable energy savings (70%). The year-on-year growth in energy savings is in line with the increase in baseline energy consumption every year.

Energy savings (Million toe) are multiplied by the average cost saved/toe of energy saved (INR/toe) to calculate the cost saved per year by implementing the technology. The implementation cost for scaling the technology at the SME level is calculated multiplying the energy savings (Million toe) by the average implementation cost/toe of energy saved (INR/toe).

The cost of implementing the technology and the energy and cost savings accrued every year is as given below:

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[7] Waste Heat Recovery – Technology and Opportunities in US Industry, http://www1.eere.energy.gov/manufacturing/intensiveprocesses/pdfs/waste_heat_recovery.pdf

[8] Detailed Project Report on WHRS in Refrigeration System by De-Super Heater Technology in Gujarat Dairy Cluster, Bureau of Energy Efficiency, 2010 - http://sameeeksha.org/pdf/Gujarat_dairy_cluster/DPR_on_De-Super_Heater_System_210_TR.pdf

[9] Detailed Project Report on Energy Efficient Oil Fired Reheating Furnace (750kg/hr) for Jamnagar Brass Cluster, Bureau of Energy Efficiency, 2010 - http://www.dcmsme.gov.in/reports/jamnagartexttile/energyefficientoilfiredreheatingfurnace750kg.pdf

Table 7: Cost-Benefit Calculation for Waste Heat Recovery Intervention

	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22	2022-23	2023-24	2024-25
Energy Savings (Million toe)	0.265	0.283	0.302	0.323	0.345	0.368	0.393	0.420	0.448
Cost Savings (INR Millions)	7,123	7,606	8,122	8,673	9,263	9,893	10,565	11,284	12,051
Cost (INR Millions)	21,676								

5.2 Optimization of boiler and steam system

Many units in SME clusters use coal as fuel for boilers. The coal consumption in these units varies depending on production capacity and facilities of the plant. Boilers are installed in the cluster units for steam generation which is used for various processes.

Most of the boilers used in the clusters are inefficient due to inferior design like single pass system, high flue gas losses and high radiation losses and low efficiencies. The low efficiency can be attributed to suboptimal loading of boiler, inferior boiler design, old/obsolete and local boilers, and absence of waste heat recovery. Thus, energy efficient boilers with higher efficiency are proposed to be replaced with the present boilers.

For our analysis, we have considered the calculations from textile cluster manual for Surat, Gujarat. Here the old low efficiency boilers are replaced with energy efficient boilers with 75% efficiency. Some of the salient features that can be considered for a high efficiency boiler is listed below:[10]

- The boiler is of multi-pass construction consisting of furnace section as first pass and number of convective tubular pass.
- The boiler is fully wet back construction, quenches streaks of flame entering it ensures complete turnaround mixing of the gases prior to entering the second pass.
- The front smoke box ensures complete turnaround and the mixing of the gases.
- The bigger diameter smoke tube ensures smooth passage of flue gases and prevent choking, clinkering at the tube ends. Further it makes cleaning easy.
- Fuel firing system consists of fixed grate made of heat resistance, cast iron, complete with furnace refractory for reducing radiation losses

The calculations for thermal energy savings and cost of technology has been taken from the referenced report. From the already implemented technology, it was identified that around 21% fuel can be saved by replacing an existing old boiler with an energy efficient boiler. The saving potential is scaled to the SME sector level by multiplying it with the thermal energy consumed

[10] Manual on Energy Conservation Measures in Textile Cluster Surat, Gujarat, Bureau of Energy Efficiency - http://sameeeksha.org/pdf/dpr/Surat_Textile.pdf

by boiler systems (approx. 3.32 Million toe). The following factors are taken into consideration while calculating the cost and energy savings across the SME sector:

- Replication potential of the technology has been limited to 30% of the units
- The achievable energy savings have been taken as 70% of the percentage saving proposed in the referenced report
- Duplication of savings due to implementation of other intervention like fuel switch (where implementation would result in boiler/ furnace replacement) is taken as 50%

The year-on-year growth in energy savings is in line with the increase in baseline energy consumption every year.

The value of cost saving/energy saved and implementation cost/energy saved has been calculated from the available DPR calculation. The energy savings (Million toe) calculated above are multiplied by the cost saved/toe of energy saved (INR/toe) to calculate the cost saved per year by implementing the technology at the SME level. The implementation cost for scaling the technology at the SME level is calculated multiplying the energy savings (Million toe) by the average implementation cost/toe of energy saved (INR/toe).

The cost of implementing the technology and the energy and cost savings accrued every year is as given below:

Table 8: Cost-Benefit Calculation Optimization of Boiler & Steam System Intervention

	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22	2022-23	2023-24	2024-25
Energy Savings (Million toe)	0.073	0.078	0.083	0.089	0.095	0.102	0.108	0.116	0.124
Cost Savings (INR Millions)	413	441	471	503	538	574	613	655	699
Cost (INR Millions)	557								

5.3 Efficient rewinding of motors

Electric motors are key components in most industries and account for a major portion of the electrical energy consumption. Thus, industries need effective motor maintenance and management strategies to minimize overall motor purchase and running costs while avoiding the pitfalls caused by unexpected motor failures or lower efficiency due to poorly rewound motors.

It is thus proposed through this intervention to adopt standard rewinding practices along with standard rewinding material to maintain the efficiency level of electric motors. For our analysis, we have adopted the calculations from the report on Technological Upgradation with High Efficiency Electric Motor (30 kW) for Gujarat Dairy Cluster. [11]

<u>Assumptions:</u>

- Electricity consumption by electric motor systems w.r.t. global industrial consumption is taken as 60%.[12]
- Percentage of motors that go for rewinding each year is assumed as 10%
- Value of energy saving %, cost saving/energy saved and implementation cost/energy saved has been calculated from the available calculations.
- The technology can be replicated in 50% of the units across the SME sector.
- The achievable energy savings have been taken as 70%.
- Cost of electricity is taken as Rs. 6.15/kWh.

The total motive load of the SME sector is calculated using the baseline electricity consumption. The average energy saving percentage from the referenced DPR calculation for one motor is found to be 4%. This gives us the total saving potential in the SME sector. The energy saved by implementing the intervention at the SME level is calculated by multiplying the energy saving potential (4%) by the calculated motive load, the replication potential of the technology across the SME sector (50%), the on-ground achievable energy savings (70%) and the percentage of motors that go for rewinding each year (10%).

The total motive load is then divided by the energy consumed by one motor/annum and the percentage of motors that go for rewinding each year (10%) to find the total number of motors required to achieve the calculated savings. The number of motors is multiplied with the savings per motor to get the total cost saving for the SME sector. The total implementation cost at SME level is calculated by multiplying the number of motors with the replication potential (50%) and the cost of rewinding one motor. Cost of rewinding one motor is taken as 40% of the cost of new motor. [13]

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[11] Detailed Project Report on Technological Upgradation with High Efficiency Electric Motor (30 kW) Gujarat Dairy Cluster, Bureau of Energy Efficiency - http://sameeeksha.org/pdf/Gujarat_dairy_cluster/DPR_on_Energy_Efficient_Motor_30kW.pdf

[12] Working Paper on Energy efficiency in electric motor systems: Technical potentials and policy approaches for developing countries, UNIDO, 2011 - https://www.unido.org/fileadmin/user_media/Services/Research_and_Statistics/WP112011_Ebook.pdf

[13] http://ecatalog.weg.net/files/wegnet/WEG-taking-a-total-cost-of-ownership-approach-to-motor-replacement-can-save-big-dollars-and-help-save-the-planet!-technical-article-english.pdf

The cost of implementing the technology and the energy and cost savings accrued every year is as given in the table below.

Table 9: Cost-Benefit Calculation for Efficient Rewinding of Motors Intervention

	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22	2022-23	2023-24	2024-25
Energy Savings (Million toe)	0.0030	0.0032	0.0034	0.0036	0.0039	0.0041	0.0044	0.0047	0.0050
Cost Savings (INR Millions)	756	809	864	922	985	1051	1123	1199	1281
Cost (INR Millions)	624								

5.4 Fuel switch

As per the Annual Report 2015 published by MoMSME, 66% of the industries use either coal, oil or firewood for their thermal energy needs. Only 9% of the industries use gas (LPG/CNG) which is a more efficient and clean fuel.

Fuel switch refers to changing the fuel used from a less efficient and polluting fuel to a more efficient and comparably more environment friendly fuel. For our analysis, we have considered the calculations from the Ahmedabad Chemical Cluster where traditional hot air generator using wood as fuel is replaced with gas fired hot air generator.[14] Some of the advantages of the proposed equipment are as follows:

- Low fuel consumption and environmental pollution
- Low maintenance and operational cost
- Complete and controlled fuel combustion
- Low radiation losses and higher rate of heat transfer

<u>Assumptions:</u>

- The calculations for thermal energy savings and cost of technology have been taken from the referenced report.
- Percentage of traditional energy (firewood) to be replaced with gas is 30%
- Energy content of wood fuel (air dry, 20% moisture) is taken as 15 GJ/t (or 15 MJ/kg)[15]

Traditional energy i.e. firewood is consumed in almost 7 lakh units in the Indian SME sector and forms almost 17% of the thermal energy consumption. For this calculation, we have assumed that 30% of the

[14] Detailed Project Report on Energy Efficient Gas Fired Hot Air Generator (30,000 kCal/hr) for Ahmedabad Chemical Cluster, Bureau of Energy Efficiency, 2010 - http://sameeeksha.org/pdf/dpr/Ahmedabad_30000.pdf

[15] http://www.ocean.washington.edu/courses/envir215/energynumbers.pdf

firewood is replaced by gas to improve energy efficiency and reduce carbon emissions in the sector. The total energy savings from this intervention are calculated by multiplying the baseline thermal energy consumption of the SME sector by the % of energy from firewood (17.29%), the percentage of firewood replaced by gas (30%), the replication of the technology across SME sector (i.e. 30%) and the achievable energy savings (70%).

The total monetary benefit from one gas generator (comprises of cost savings in use of wood and expense of using LNG and electricity) is used to calculate the total cost savings accrued due to the implementation of this technology.

The cost of implementing the technology and the energy and cost savings accrued every year is as given below:

Table 10: Cost-Benefit Calculation for Fuel Switch Intervention

	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22	2022-23	2023-24	2024-25
Energy Savings (Million toe)	1.35	1.45	1.54	1.65	1.76	1.88	2.01	2.14	2.29
Cost Savings (INR Millions)	9527	10173	10863	11600	12389	13232	14132	15092	16119
Cost (INR Millions)	24087								

5.5 Energy Efficient Lighting

Lighting systems form 10% of the total energy consumed by the Indian industry[16] which largely uses incandescent lamps for lighting purposes. Though the latest technical advancements in lighting provide with a lot of energy efficient options, the energy efficient options are a little expensive in comparison to the old incandescent options and tube lights. However, the payback time considering the savings it provides is quite short and the lifespan is much larger which makes them much more attractive.

There are several lighting options that are available in the market. The two main types of energy efficient light bulbs available in India are the Compact Fluorescent Lamps (CFLs) and Light Emitting Diodes (LEDs). For our analysis, we have considered replacement of T8 tube lights with LED tube lights for the Kohlapur Foundry Cluster.[17]

[16] Conservation of Energy: a Case Study on Energy Conservation in Campus Lighting in an Institution, International Journal of Modern Engineering Research (IJMER), Vol.3, Issue.4, Jul - Aug. 2013 pp-1939-1941 - http://www.ijmer.com/papers/Vol3_Issue4/AN3419391941.pdf

[17] Cluster Profile Report Kolhapur Foundry Industry, Small Industries Development Bank of India - http://sameeeksha.org/brouchres/Cluster-Profile-Report-Kolhapur-(Foundry)-Cluster.pdf

Assumptions:

- Typical lighting load in an MSME cluster as a percentage of total electrical load is taken as 5%
- The technology can be replicated in 50% of the units across the SME sector
- Average value of all the technical interventions has been considered for energy saving and cost of technology.
- The achievable energy savings have been taken as 70%.
- Cost of electricity is taken as Rs. 6.15/kWh.

The average energy saving percentage from the calculations is found to be 50%. This is multiplied by the electrical energy consumption by lighting systems, the replication potential of the technology across the SME sector (50%) and the on-ground achievable energy savings (70%) to calculate the energy savings at the SME level. The year-on-year growth in energy savings is in line with the increase in baseline energy consumption every year.

Electrical energy savings (Million toe) are multiplied by the cost of electricity (INR 6.15/kWh) to calculate the cost saved per year by implementing the technology. The implementation cost for scaling the technology at the SME level is calculated multiplying the energy savings (Million toe) by the implementation cost per unit of energy saved (INR/Million toe).

The cost of implementing the technology and the energy and cost savings accrued every year is as given below:

Table 11: Cost-Benefit Calculation for Energy Efficient Lighting Intervention

	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22	2022-23	2023-24	2024-25
Energy Savings (Million toe)	0.040	0.043	0.046	0.049	0.052	0.056	0.060	0.064	0.068
Cost Savings (INR Millions)	2879	3078	3288	3509	3747	4002	4274	4565	4875
Cost (INR Millions)	6966								

5.6 Efficient Pumping Systems

Pumping systems consist of pumps, driver, pipe installation and controls. Energy efficiency can be achieved in a pumping system in the following ways: [18]

- Maintenance - Better maintenance will reduce lowers pump system efficiency, pump wear and save costs and energy

[18] Electrical Engineering Portal, 14 energy-efficiency improvement opportunities in pumping systems - http://electrical-engineering-portal.com/14-energy-efficiency-improvement-opportunities-in-pumping-systems

- Monitoring - Monitoring in conjunction with operations and maintenance can be used to detect problems and determine solutions to create a more efficient system. Monitoring can determine clearances that need be adjusted, indicate blockage, impeller damage, inadequate suction, operation outside preferences, clogged or gas-filled pumps or pipes, or worn out pumps.

- Controls – An effective control strategy will shut off unneeded pumps or reduce the load of individual pumps. Remote controls enable pumping systems to be started and stopped relatively quickly and accurately, and reduce the required labour costs.

- Reduction of demand - Holding tanks can be used to equalize the flow over the production cycle, enhancing energy efficiency and potentially reducing the need to add pump capacity.

- More efficient pumps – Use of new, more efficient pumps with suitable specific pressure head and flow rate capacity requirements.

- Proper pump sizing – This can be implemented when a pump may be incorrectly sized for current needs if it operates under throttled conditions, has a high bypass flow rate, or has a flow rate with large variations.

- Multiple pumps for varying loads - The use of multiple pumps is often the most cost-effective and most energy-efficient solution for varying loads, particularly in a static head-dominated system. Alternatively, adjustable speed drives could be considered for dynamic systems. Parallel pumps offer redundancy and increased reliability.

- Adjustable speed drives (ASDs) – Use of VFDs to better match speed to load requirements.

- Proper pipe sizing - Energy may be saved by reducing losses due to friction through the optimization of pipe diameters.

- Replacement of belt drives - Some pumps use standard V-belts which tend to stretch, slip, bend and compress, which lead to a loss of efficiency. Replacing standard V-belts with cog belts can save energy and money, even as a retrofit.

For our analysis, we have considered the installation of VFDs[19] and energy efficient pumps which reduces electricity consumption, production cost and environmentally harmful greenhouse gases emission.[20]

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[19] Detailed Project Report on Variable Frequency Drive for Jet Machine Pump (10 HP) for Surat Textile Cluster, Bureau of Energy Efficiency, 2010 - http://sameeeksha.org/pdf/dpr/surat_VFD.pdf

[20] Detailed Project Report on Energy Efficient Pump for Jet Dyeing Machine (150kg) for Surat Textile Cluster, Bureau of Energy Efficiency, 2010 - http://sameeeksha.org/pdf/dpr/surat_150kg.pdf

Assumptions:

- Average value of both the DPRs of thermal energy saving percentage and cost of technology has been considered.
- In an industry, electrical energy consumed by pumps is taken as 5% of the total energy consumption. [21]
- The technology can be replicated in 40% of the units across the SME sector.
- The achievable energy savings have been taken as 70%.
- Cost of electricity is taken as Rs. 6.15/kWh.

The average energy saving percentage from the calculations is found to be 24%. This is multiplied by the electrical energy consumption by pumping systems, the replication potential of the technology across the SME sector (40%) and the on-ground achievable energy savings (70%). The year-on-year growth in energy savings is in line with the increase in baseline energy consumption every year.

Electrical energy savings (Million toe) are multiplied by the cost of electricity (INR 6.15/kWh) to calculate the cost saved per year by implementing the technology. The implementation cost for scaling the technology at the SME level is calculated multiplying the cost savings (INR) by the payback period of the technology.

The cost of implementing the technology and the energy and cost savings accrued every year is as given below:

Table 12: Cost-Benefit Calculation for Efficient Pumping Systems Intervention

	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22	2022-23	2023-24	2024-25
Energy Savings (Million toe)	0.016	0.017	0.018	0.019	0.020	0.022	0.023	0.025	0.026
Cost Savings (INR Millions)	1118	1195	1277	1362	1455	1554	1659	1772	1893
Cost (INR Millions)	874								

5.7 Improvement in Insulation

Keeping thermal losses in heat generation, transfer and storage to a minimum considerably reduces the energy consumption of a system. In processes where temperatures in pipes, furnaces or storage tanks must remain within narrow margins, proper insulation makes the task much easier. Consequently, the overall process efficiency becomes more stable. Proper insulation also helps reduce the plant and process maintenance work.

[21] Triangular Wave technologies, Equipment Application Fact Sheet Series, http://www.triangularwave.com/PumpProtectionFactSheet.htm

For our analysis, we have considered the fuel savings due to improvement in insulation from two[22] different sources[23]. Average savings from these two documents is coming as 30%

Assumptions:

- The technology can be replicated in 30% of the units across the SME sector.
- Percentage savings considered from the intervention is the average of savings from two different sources.

The achievable energy savings have been taken as 70%.The average energy saving percentage from the calculations is found to be 30%. This is multiplied by the targeted thermal energy consumption (in Million toe) for insulation systems (4.93Million toe) as calculated in the previous section of this report. The replication potential of the technology across the SME sector (30%) and the on-ground achievable energy savings (70%). The year-on-year growth in energy savings is in line with the increase in baseline energy consumption every year.

Energy savings (Million toe) are multiplied by the average cost saved/toe of energy saved (INR/toe) to calculate the cost saved per year by implementing the technology. The implementation cost for scaling the technology at the SME level is calculated multiplying the energy savings (Million toe) by the average implementation cost/toe of energy saved (INR/toe).

The cost of implementing the technology and the energy and cost savings accrued every year is as given below:

Table 13: Cost-Benefit Calculation for Improvement in Insulation Intervention

	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22	2022-23	2023-24	2024-25
Energy Savings (Million toe)	0.314	0.335	0.358	0.382	0.408	0.436	0.466	0.498	0.531
Cost Savings (INR Millions)	12270	13102	13991	14940	15956	17041	18200	19438	20759
Cost (INR Millions)	10517								

[22] Reliable Plant.Com - http://www.reliableplant.com/Read/15871/maximize-system-energy-efficiency-with-proper-insulation

[23] Source: EY Analysis

5.8 Use of VFDs for motor control

A Variable Frequency Drive (VFD) is a type of motor controller that drives an electric motor by varying the frequency and voltage supplied to the electric motor. Frequency is directly related to the motor's speed (RPMs). In other words, the faster the frequency, the faster the RPMs go.

Variable Speed Drives are used in any application in which there is mechanical equipment powered by motors; the drives provide extremely precise electrical motor control, so that motor speeds can be ramped up and down, and maintained, at speeds required; doing so utilizing only the energy required, rather than having a motor run at constant (fixed) speed and utilizing an excess of energy.

For our analysis, we have considered the calculations from Pali Textile Cluster which utilizes VFD in thermic fluid pump motor of Thermopac. [24]

Assumptions:

- Electricity consumption by motor systems w.r.t. total energy consumption of the industry is taken as 60%.
- The technology can be replicated only in 40% of the units across the SME sector as some units have already installed variable frequency drives.
- The achievable energy savings have been taken as 70%.
- Duplication of savings due to implementation of other intervention for motors like efficient rewinding of motors, improvement in pumping and compressor systems etc. is taken as 50%
- Cost of electricity is taken as Rs. 6.15/kWh.

The average energy saving percentage observed in the reviewed reports is around 53%. To calculate the energy savings at SME level, this is multiplied by various factors like - percentage of energy consumed by motors (60%), replication potential of the technology (40%), on-ground achievable energy savings (70%) and duplication in savings (50%). The year-on-year growth in energy savings is in line with the increase in baseline energy consumption every year.

Electrical energy savings (Million toe) are multiplied by the cost of electricity (INR 6.15/kWh) to calculate the cost saved per year by implementing the technology. The implementation cost for scaling the technology at the SME level is calculated multiplying the cost savings (INR) by the payback period of the technology.

Energy savings (Million toe) are multiplied by the average cost saved/toe of energy saved (INR/toe) to calculate the cost saved per year by implementing the technology. The implementation cost for scaling the technology at the SME level is calculated multiplying the cost of one VFD, controller, panel and labour cost with the number of motors required to achieve the calculated savings.

The cost of implementing the technology and the energy and cost savings accrued every year is as given below:

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[24] Detailed Project Report on provision of VFD in Thermic Fluid Pump of Thermopac for Pali Textile Cluster, Bureau of Energy Efficiency, 2010 - http://sameeeksha.org/pdf/dpr/pali_thermopac.pdf

Table 14: Cost-Benefit Calculation for VFDs for Motor Control Intervention

	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22	2022-23	2023-24	2024-25
Energy Savings (Million toe)	0.23	0.24	0.26	0.28	0.29	0.31	0.34	0.36	0.38
Cost Savings (INR Millions)	16,185	17,304	18,484	19,725	21,066	22,498	24,028	25,662	27,407
Cost (INR Millions)	6584								

5.9 Efficient compressors

Compressed air is one of the most widely used forms of energy throughout many industries. Compressed air can be one of the most expensive forms of energy for manufacturing plants, often using more energy than other equipment. With many air compressors running at very low efficiencies, there's often plenty of room for improvement. Fortunately, 50% of compressed air systems at small- to medium-sized industrial facilities have opportunities for low-cost energy conservation.[25]

Compressor system efficiency can be improved with the following approaches:

- Improve the Quality of the Air Intake
- Improve System Design
- Minimize Pressure Drop
- Regular maintenance of compressor systems

For our analysis, we have considered the calculation from following interventions to increase the efficiency of compressors:

1. Replacement of standard V-belt with cogged V-belt
2. Replacement of old, inefficient air compressor with energy efficient air compressor
3. Reduction of Cut off Pressure for compressor
4. Repair of Compressor

<u>Assumptions:</u>

- Average value of all the technical interventions has been considered for energy saving percentage and cost of technology.
- Electricity consumption by compressors w.r.t. total energy consumption of the industry is assumed as 10%.
- The technology can be replicated in 40% of the units across the SME sector.
- The achievable energy savings have been taken as 70%.

[25] Quincy Compressors, How to Make Your Air Compressor More Efficient - http://www.quincycompressor.com/how-to-make-your-air-compressor-more-efficient/

- Cost of electricity is taken as Rs. 6.15/kWh.

The average energy saving percentage (30%) is multiplied by the electrical energy consumption by pumping systems, the replication potential of the technology across the SME sector (40%) and the on-ground achievable energy savings (70%) to calculate the energy savings at the SME level. The year-on-year growth in energy savings is in line with the increase in baseline energy consumption every year.

Electrical energy savings (Million toe) are multiplied by the cost of electricity (INR 6.15/kWh) to calculate the cost saved per year by implementing the technology. The implementation cost for scaling the technology at the SME level is calculated multiplying the cost savings (INR) by the payback period of the technology.

The cost of implementing the technology and the energy and cost savings accrued every year is as given below:

Table 15: Cost-Benefit Calculation for Efficient Compressors Intervention

	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22	2022-23	2023-24	2024-25
Energy Savings (Million toe)	0.029	0.031	0.033	0.035	0.038	0.040	0.043	0.046	0.049
Cost Savings (INR Millions)	2073	2216	2367	2526	2698	2881	3077	3287	3510
Cost (INR Millions)	5376								

6 Impact Assessment of Technical Interventions

After selection of the technical interventions and calculation of their energy consumption w.r.t. the baseline, the next step involves evaluating the interventions on a set of criteria (financial, environmental, economic and social) to gauge the benefits incurred from each technology and to decide the priority of on the ground large scale implementation.

6.1 Decision Support Tool Architecture

An excel spreadsheet based Decision Support Tool (DST) has been developed for this assessment. The DST will assess the impact of implementing each intervention on a set of fixed criteria like cost of implementation, fuel savings, emission reduction, maturity of technology, ease of implementation etc. To perform this assessment, two different analysis will form part of the DST tool – Cost Benefit Analysis (CBA) and Multi Criteria Analysis (MCDA) as shown in the figure below.

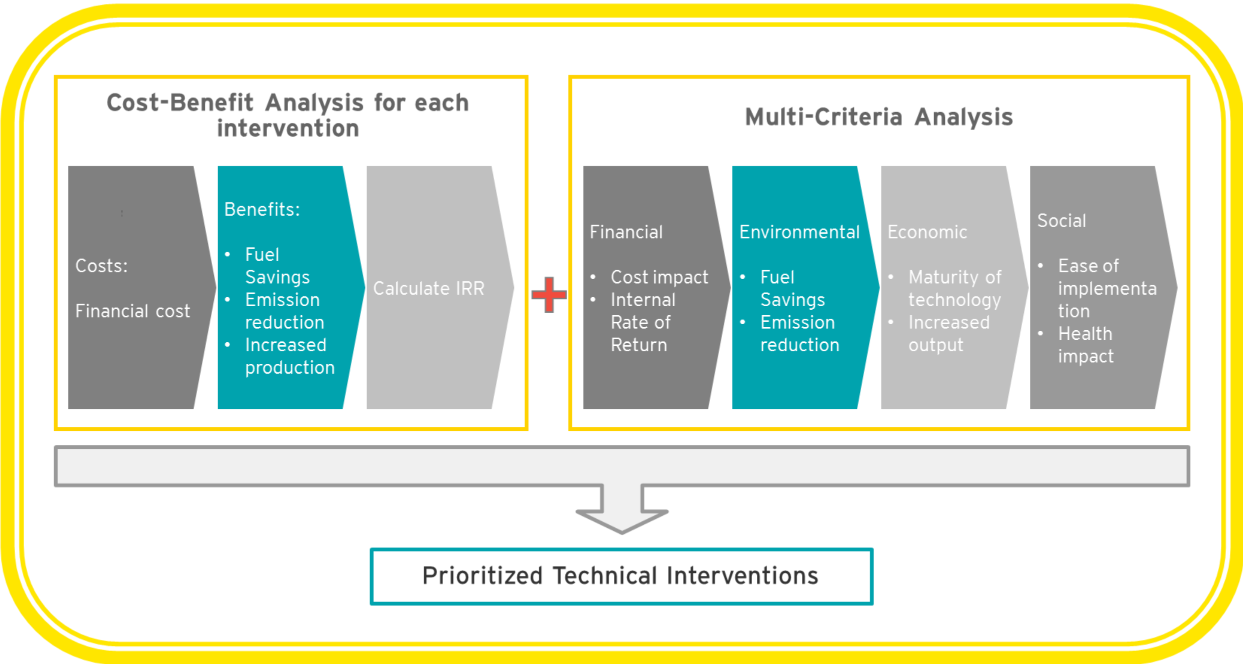


Figure 6: Decision Support Tool Architecture

As calculated in the previous chapter, cost of technology and amount and cost of fuel saved forms an input to the decision support tool. Other than this, emission reduction, maturity of technology, ease of implementation, internal rate of return are also inputs to the DST. Most of this information is collected through secondary research and consultations with the relevant stakeholders. The output of DST would be the prioritized interventions that can be implemented in the SME clusters.

In this report a scenario calculation using the DST has been shown in the subsequent sections. The assumptions used for building the scenario have been listed throughout the report in various sections. The excel spreadsheet based Decision Support Tool (DST) however gives an opportunity to the users to develop different scenarios by changing various parameter values like replication potential of technologies, cost of electricity, ease of implementation, maturity of technology and effect of O&M cost of interventions.

6.2 Cost Benefit Analysis

A cost-benefit analysis (CBA) is a systematic process for calculating and comparing benefits and costs of a project or decision. A CBA has two purposes:

- To determine if the project or decision is a sound investment or decision (i.e., a justification of feasibility or advantage)
- To provide a basis for comparing projects or decisions. It involves comparing the total expected cost of each option against the total expected benefits, to see whether the benefits outweigh the costs, and by how much.

This section of the report provides outcomes from the analysis of cost and benefits related to various interventions. Payback period calculation and benefit cost ratio is a part of this analysis.

6.2.1 Assumptions for Cost – Benefit Analysis

- For the purpose of calculating the benefit-cost ratios, implementation of all the interventions have been considered in the 2016 -17 period. The reason for making such an assumption is to find the benefit-cost ratio considering the savings for the same number of years after implementation of interventions.
- Reference cost of interventions has been taken from the documents of year before 2016. It is understood that over the time span, cost of a particular technology could change. However, to maintain simplicity of calculation in CBA and due to limited availability of reliable information, it is assumed that cost of a particular technology at the time of implementation is same as mentioned in the source documents. Also "price per toe" value for interventions has been taken from the various source DPRs considered in the study.
- No depreciation or appreciation of rupee has been considered over the period of time for performing CBA. Also, no effect of GDP growth of the nation has been considered in this analysis.
- No depreciation of equipment related to various proposed energy efficient interventions has been considered in the study. For calculating monetary savings of interventions, cost per unit of electricity has been assumed as 6.15 INR/Kwh.
- Savings from the possibility of improvement in the operating procedure is not a part of this analysis.
- For the scenario calculation, replication potential and achievable savings has been assumed as given in Table 4.

6.2.2 Cost Benefit Analysis Input

1. Cost of interventions:

   Following table shows the cost related to various interventions

Table 16: Cost of implementing Energy Efficient Interventions

Interventions	Cost (INR Millions)
Waste heat recovery	21,676
Insulation Improvement	10,517
Lighting - LEDs Installation	6,966
New boiler installation	557
VFD installation for motors	6,584
Efficient pumping system	874
Compressors	5,376
Rewinding of motors	624
Fuel Switch	24,087
Total	**77,262**

Above cost, as explained in the previous chapter, represents the cost of implementing the energy efficient intervention at the SME level.

2. Present and future monetary savings from energy efficient interventions: Future monetary savings due energy efficient interventions has been shown in detail in the other section of this chapter

3. Discount Rate: It is used to calculate the present values of the future cash flows.

6.2.3 Cost Benefit Analysis Output

Following represents the two outputs of the cost benefit analysis:

1. **Benefit Cost Ratio (BCR):**

Benefit-Cost Ratio (BCR) directly compares benefits and costs. To calculate the BCR, total discounted benefits have been divided by the total discounted costs. Cost of interventions implementation for BCR calculation, as discussed in the assumption, has been considered to be incurred in the year 2016. As 2016 is the present year, therefore discounted value and future value of all the interventions cost is same.

Table below shows the future values of cash flows.

Table 17: Costs and Benefits of each intervention

Interventions - Future Value (INR Millions)	Cost (INR Millions) (2016-2017)	Future Value of Savings (INR Millions)								
		2016-17	2017-18	2018-19	2019-20	2020-21	2021-22	2022-23	2023-24	2024-25
Waste heat recovery	-21676	7123	7606	8122	8673	9263	9893	10565	11284	12051
Insulation Improvement	-10517	12270	13102	13991	14940	15956	17041	18200	19438	20759
Lighting - LEDs Installation	-6966	2879	3078	3288	3509	3747	4002	4274	4565	4875
New boiler installation	-557	413	441	471	503	538	574	613	655	699
VFD installation for motors	-6584	16185	17304	18484	19725	21066	22498	24028	25662	27407
Efficient pumping system	-874	1118	1195	1277	1362	1455	1554	1659	1772	1893
Compressors	-5376	2073	2216	2367	2526	2698	2881	3077	3287	3510
Rewinding of motors	-624	756	809	864	922	985	1051	1123	1199	1281
Fuel Switch	-24087	9527	10173	10863	11600	12389	13232	14132	15092	16119
Total	**-77262**	**52344**	**55925**	**59727**	**63760**	**68096**	**72727**	**77672**	**82954**	**88595**

Benefit cost ratio has been calculated after summing all the monetary savings (INR) in the present value terms (resulting from energy efficient interventions) for 2016 -2025. Formula used to calculate the BCR is as follows:

Benefit- Cost Ratio (BCR) = Total Cost /Total Benefit

Sensitivity analysis with different discount rate: To understand how benefit cost ratio is impacted with different discount rates, three different discount rates have been considered. Interest rate on financing of energy efficiency interventions varies from one SME sector to another. To keep simplicity in the calculation of BCR, all interventions have been applied with the uniform discount rate to calculate the present value of monetary savings. However, three different discount rates have been considered to perform the sensitivity analysis.

Following three discount rate variations have been considered to showcase the benefit cost ratio of all the interventions:

1) 8%
2) 10%
3) 12%[26]

BCR Interpretation: BCR value of greater than 1 indicates that net present value (NPV) of the project benefits outweigh the NPV of the costs. Since all the energy efficient interventions have BCR value greater than 1, it can be interpreted that all the interventions can be considered for implementation.

Following table represents the BCR values of different interventions at above mentioned three different discount rates.

Table 18: Benefit Cost Ratio for different discount rates

Benefit Cost Ratio			
Interventions	**8% Discount Rate**	**10% Discount Rate**	**12% Discount Rate**
Waste heat recovery	2.83	2.46	2.63
Insulation Improvement	10.04	8.74	9.35
Lighting - LEDs Installation	3.56	3.10	3.32
New boiler installation	6.39	5.56	5.95
VFD installation for motors	21.18	18.44	19.73
Efficient pumping system	11.02	9.59	10.26
Compressors	3.32	2.89	3.09
Rewinding of motors	10.44	9.09	9.73
Fuel Switch	3.40	2.96	3.17

[26] Economics in Policy Making – Discounting and Time Preferences, The New Economics Foundation, April 2013, Page 3, http://anyflip.com/iebd/jvkb/basic

2. Internal Rate of Return (IRR):

IRR analysis begins with a cash flow stream, a series of net cash flow results expected from the investment (Implementation cost of energy efficient interventions). Stream of cash flows in the CBA analysis is the monetary savings achieved from implementation of the energy efficient interventions. Future cash flows from the interventions has already been shown in the previous sections of this chapters. Following table shows the IRR of each intervention:

Table 19: Technical Interventions and their Internal Rate of Return

Energy Efficient Interventions	IRR
Waste heat recovery	36%
Insulation Improvement	123%
Lighting - LEDs Installation	46%
New boiler installation	80%
VFD installation for motors	253%
Efficient pumping system	135%
Compressors	43%
Rewinding of motors	128%
Fuel Switch	44%

Top 3 interventions in terms of highest IRR are:

- VFD installation for motors
- Efficient pumping system
- Rewinding of motors

6.3 Multi Criteria Analysis (MCA)

Every decision is made within a decision environment, which is defined as the collection of information, alternatives, values and preferences available at the time when the decision must be made. The difficult point in decision-making is the multiplicity of the criteria set for judging the alternatives. The objectives are usually conflicting and, in most of the cases, different groups of decision-makers are involved in the process. MCA is a general framework for supporting complex decision-making situations with multiple and often conflicting objectives that stakeholder groups and/or decision-makers value differently.

6.3.1 Assumption for Multi Criteria Analysis

- Considering practical challenges in implementation, not all interventions have been considered for implementation in the same year. Nine interventions considered in the study have been implemented from 2016 – 2025 period (period of 9 years) and prioritised on the basis of the weighted score calculated in Multi Criteria Analysis (MCA).Each year only one intervention has been implemented.

6.3.2 Approach to perform MCA

1. **Identification of MCA Criteria:**

MCA in the study helps to evaluate the different interventions on many criteria related to health, cost, savings, ease etc. Following criteria have been identified for MCA in the study

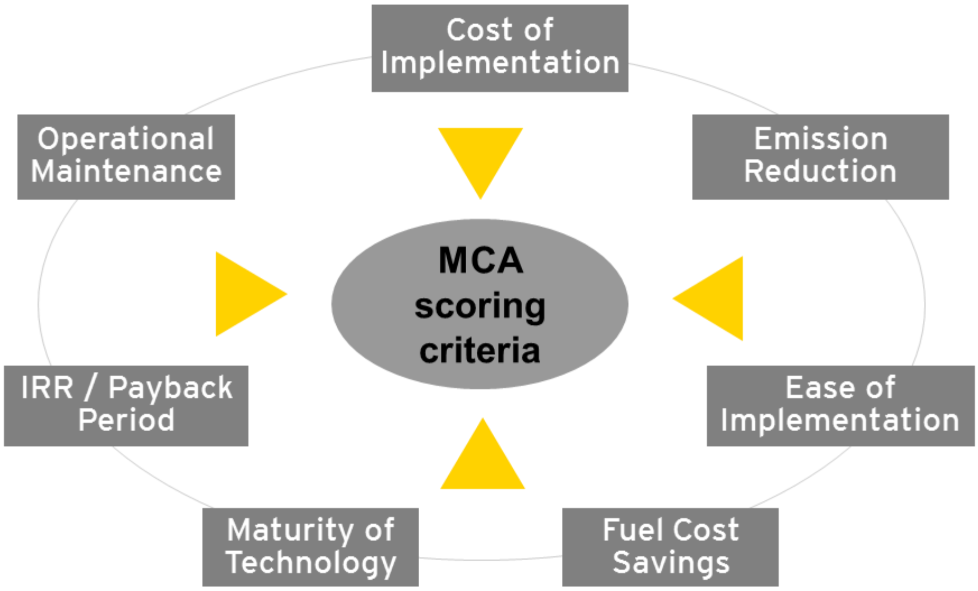


Figure 7: MCA Scoring Criteria

2. **Assigning weights to MCA criteria:** Weights shows the relative importance of criteria in the multi-criteria problem under consideration. Weights are determined through the stakeholder consultations. Stakeholders from different backgrounds had been consulted to assign the weights on different criteria.

Following table illustrates the score provided by different stakeholders and average score related to each criterion used for MCA in the tool.

Table 20: Assigning weights to MCA Criteria

Criteria Weights							
Stakeholder Consultation	Cost of implementation	Ease of implementation	Cost saving	Emission reduction	IRR/ Payback Period	Maturity of technology	Operational Maintenance
Stakeholder 1	5	3	5	4	5	3	5
Stakeholder 2	4	4	3	1	4	4	3
Stakeholder 3	4	4	4	4	4	4	4
Stakeholder 4	5	3	5	3	4	4	4
Stakeholder 5	2	2	2	1	1	3	2
Average Score	**4**	**3.2**	**3.8**	**2.6**	**3.6**	**3.6**	**3.6**

6.3.3 MCA Inputs

1. Criteria Weight: Numerical weights are assigned to define, for each criterion, the relative valuations of a shift between the top and bottom of the chosen scale.
2. Intervention value calculated against each criterion

Following three types of inputs are used in the tool for MCA:

- **Inputs from CBA**: Tool extracts the interventions cost and monetary savings values from the CBA calculation.
  - Cost of implementation (INR Lakhs)
  - Cost savings (INR Lakhs)

- **User specific inputs related to MCA:** The DST tool gives freedom to user to enter the values in the range of “0” to “10” for few selected criteria with respect to each intervention. More preferred options score higher on the scale, and less preferred options score lower. “0” represents the least preferred option, and “10” is associated with the most preferred option. User can enter any value from “0” to “10”. Following is the list of MCA related user options provided in DST.

  1) **Ease of implementation**
     The ease of implementation of technology can be decided by the user on the following basis:
     - **Time required for installation:** Example: An intervention which can be implemented in 2-3 days would be easy to implement in comparison to a technology which requires a time period of 10-15 days.
     - **Downtime of the plant:** During the implementation, there may be a requirement to shut down the plant process or decrease the production of the plant. This factor shall be judged by the user while providing a score to “Ease of Implementation” criteria.
  2) **Maturity of technology**
     Following factors shall be considered by user while deciding the “Maturity of technology” value for each intervention

- Ease of use for both non-experts and professionals
- Reduction in the rate of new breakthrough advances related to it. A mature technology will have only incremental improvements over the year

3) Effect on the operational maintenance cost:

Following question shall be considered by user while deciding on the "Effect on Operational Maintenance Cost"

- Will new technology increase or decrease the operational maintenance cost?

Other Inputs

- **Emission Reductions (tCO_2):** Implementation of energy efficient interventions also results in the reduction of CO_2 emissions due to saving of fuel when compared with the baseline energy consumption scenario. Emission reductions has been calculated by multiplication of the following two values
  - "**tCO_2/Million toe**" factor[27] related to different fuel
  - Million toe saved each year

Following table represents the emission reductions due to various interventions considered in the study:

Table 21: Emission Reduction (in tCO_2) due to each Intervention

Interventions	Emission Reduction (in tCO_2)
Waste Heat Recovery	10,26,511
Insulation Improvement	12,16,655
Lighting - LEDs Installation	3,83,863
New boiler installation	2,83,183
VFD installation for motors	21,58,003
Efficient Pumping system	1,49,035
Compressors	2,76,381
Rewinding of motors	28,240
Fuel Switch	28,48,437

Implementation of energy efficient interventions shall result in total reductions of 83,70,307 tCO_2 in 2016-2017 period considering that all the interventions have been implemented in this period Also, please note that payback period (in years) has been calculated from the cost and savings values sourced from CBA.

[27] US Energy Information Administration (EIA), Frequently Asked Questions, June 14, 2016 - https://www.eia.gov/tools/faqs/faq.cfm?id=73&t=11

6.3.4 MCA Output

MCA output is a performance matrix or consequence table, in which each row describes the performance of the option against each criterion. Table below shows the performance matrix template used for MCA in the decision support tool.

Table 22: Performance Matrix used for Multi Criteria Analysis

MULTI- CRITERIA ANALYSIS (MCA)								
Criteria →		Cost of implementation (INR Lakhs.)	Ease of implementation	Cost savings (INR Lakhs)	Emission reductions (tco2)	Payback Period	Maturity of technology	Effect on the operational maintenance cost
Assigned Weights →		W1	W2	W3	W4	W5	W6	W7
Score	Intervention 1		Values input by user				Values input by user	Values input by user
	Intervention 2							
	Intervention 3							
Score values conversion to %	Intervention 1							
	Intervention 2							
	Intervention 3							
Weighted score	Intervention 1							
	Intervention 2							
	Intervention 3							

Total Weighted Score (Interventions): Total score of any intervention would be the summation of "weighted scores" for all the criteria. MCA helps user to know the priority of various policies. MCA helps in the prioritisation of the implementation of energy efficient interventions. Interventions with the highest weighted score can be implemented earlier and they will reap more and quicker benefits as compared to other interventions. For ease of implementation, interventions have been staggered and each year only one intervention has been implemented in the study. The intervention with highest weighted score has been considered for implementation in 2016-17. All nine technologies have been considered for implementation from 2016 – 2025 period (period of nine years). Following table shows the staggered implementation pattern considered in this study on the basis of MCA results.

Table below shows the weighed score calculated for each of the interventions. Based on the weighed score, the priority of the interventions is decided. Intervention with the highest weighed score has the highest priority and vice versa.

Table 23: Multi Criteria Analysis Output

MCA OUTPUT									
Criteria →		Cost of implementation (INR Lakhs.)	Ease of implementation	Cost savings (INR Lakhs)	Emission reductions (tco2)	Payback Period	Maturity of technology	Effect on the operational maintenance cost	FINAL SCORE
Assigned Weights →		4	3.2	3.8	2.6	3.6	3.6	3.6	
Weighted score	Waste Heat Recovery	0.4	3.2	1.6	0.9	0.0	3.6	0.0	**9.7**
	Insulation Improvement	2.3	3.2	2.9	1.1	3.0	3.6	0.0	**16.0**
	Lighting - LEDs Installation	2.9	3.2	0.6	0.3	0.9	3.6	0.0	**11.5**
	New boiler installation	4.0	3.2	0.0	0.2	2.3	3.6	0.0	**13.4**
	VFD installation for motors	3.0	3.2	3.8	2.0	3.6	3.6	0.0	**19.1**
	Efficient pumping system	3.9	3.2	0.2	0.1	3.1	3.6	0.0	**14.1**
	Compressors	3.2	3.2	0.4	0.2	0.6	3.6	0.0	**11.2**
	Rewinding of motors	4.0	3.2	0.1	0.0	3.0	3.6	0.0	**13.9**
	Fuel Switch	0.0	3.2	2.2	2.6	0.7	3.6	0.0	**12.3**

As per the final scores given above, the top three prioritized technical interventions are VFD installation for motors, improvement in insulation systems and efficient pumping system. However it may be noted that the results of the calculations will change as per the user inputs in the DST. These results reflect only one output simulation done for reference.

Table 24: Implementation of Interventions on the basis of MCA results

Interventions	Implementation Year
VFD installation for motors	2016-17
Insulation Improvement	2017-18
Efficient pumping system	2018-19
Rewinding of motors	2019-20
New boiler installation	2020-21
Fuel Switch	2021-22
Lighting - LEDs Installation	2022-23
Compressors	2023-24
Waste heat recovery	2024-25

Savings Impact on Energy Consumption Baseline

Implementation of the mentioned interventions will result in the shifting of the projected baseline energy consumption in the SME sector. It would be difficult to provide a certain energy consumption trajectory at this point of time. However, we believe that two realistic scenarios can be considered to show the impact/shift on the SME sector energy consumption because of identified energy efficient interventions. These two scenarios are as follows:

1) **High Energy Savings Scenario**: This considers the high economic growth scenario and considers that an additional 10% savings are possible because of high energy consumption as compared to baseline scenario.

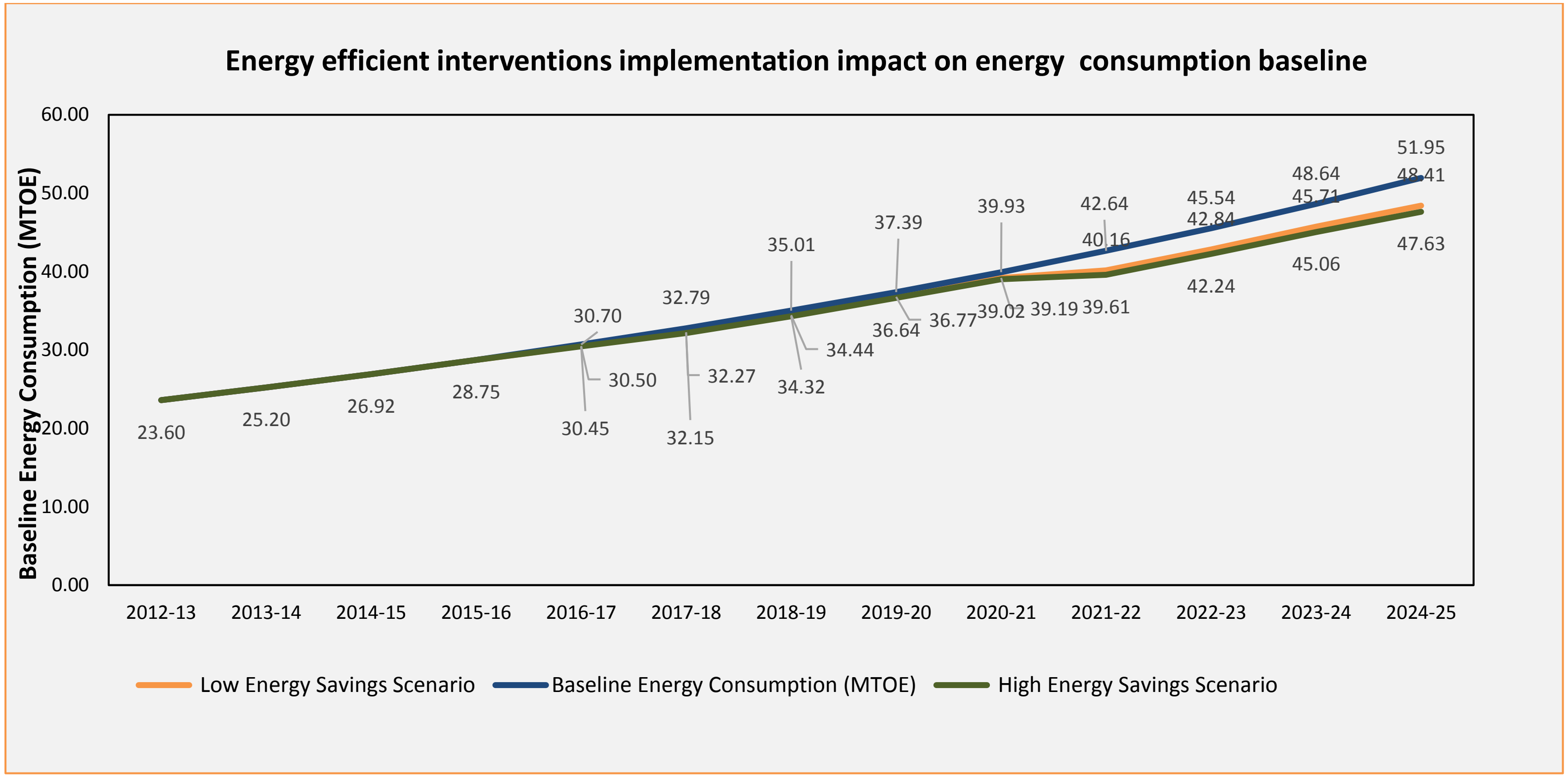
2) **Low Energy Savings Scenario**: This considers the low economic growth and considers a 10% lesser savings than what has been projected as compared to the baseline scenario.

Table 25: Energy Consumption in High & Low Growth Scenarios

Total Energy Consumption (Million toe) in SME sector in High and Low Growth Scenarios		
Year	**High Energy Savings Scenario**	**Low Energy Savings Scenario**
2012-13	23.60	23.60
2013-14	25.20	25.20
2014-15	26.92	26.92
2015-16	28.75	28.75
2016-17	30.45	30.50
2017-18	32.15	32.27
2018-19	34.32	34.44
2019-20	36.64	36.77
2020-21	39.02	39.19
2021-22	39.61	40.16
2022-23	42.24	42.84
2023-24	45.06	45.71

2024-25	47.63	48.41

Shift in the baseline energy consumption projections has been shown below by plotting the projections from the above two scenarios against the baseline energy consumption.



7 Energy Efficiency Strategy

The total energy consumed by the MSME sector for 2016-17 has been estimated in the Report of The Working Group on Power for Twelfth Plan by the GoI at around 30.70 Million toe. Through the energy audits under the BEE SME program, it was estimated that the average saving potential through energy efficiency interventions is around 19% i.e. 5.76 Million toe. It was however noted that the penetration achieved was only 17% i.e. only 17% of the units implemented the suggested measures.[28]

In the past, the Ministry of MSME has launched several schemes for large scale penetration of energy efficiency technology interventions in the SME units. Specific units within a cluster are chosen for the energy audits and the identified interventions are implemented within the units. However, a rebound effect has been observed as soon as the program gets over. This implies that after the program completion there is almost negligible replication of the suggested EE technologies which leads to very low energy savings from the cluster as a whole.

A few factors can be attributed to the reluctance and lack of enthusiasm of unit owners in implementation of the suggested measures. Some of these factors are availability of finance, adequate skills, time requirement, conflicting investment priorities and decision making ability. Figure below gives a little more information about these factors and the probable solutions around them.

FACTOR	CHALLENGE	PROPOSED RECOMMENDATION
Availability of Finance	Limited risk appetite of the unit owners to finance the energy efficient interventions	▸ Support in financing the initial capital cost of the interventions
Adequate Skill	Existing manpower needs to be trained about energy efficiency	▸ Train operators through workshops ▸ Hired trained operator through MSME Tool Rooms and Training Centres and other similar institutions
Time Availability	All responsibility lies with the unit owner who seldom gets time to do the techno-financial analysis about energy efficient equipment	▸ Provide support regarding purchase of energy efficient equipment by making the list of equipment suppliers accessible to the unit owners
Decision Making Ability	Due to limited knowledge about energy efficiency, most of the unit owners lack the conviction	▸ Develop an aggregator model by strengthening local level agency like cluster associations to support units in decision making

Figure 8: Proposed Recommendations for SME sector

The project report till now covers the selected interventions and their impact assessment on energy consumption, emission reduction and capital expenditure. In this chapter of the report, we will try and cover some recommendations that will support in overcoming the factors listed above

[28] Estimated average saving potential and achieved penetration percentage has been calculated from BEE SME Program reports for Solapur Textile Cluster, Gujarat Dairy Cluster and Jamnagar Brass Cluster.

and thus will lead to the successful implementation of the suggested interventions in the SME units. For each of the mentioned strategy, the challenges faced on the ground, the activities to be performed and the outcomes have been specified.

Recommendation 1: Support SME Units in purchase of energy efficient equipment

Challenges:

Quality of machines and adoption of new technologies has remained a challenge for the units as information on existing EE equipment suppliers was not readily available. Though a detailed list of equipment suppliers prepared under the JICA-SIDBI MSME Energy Saving Project (Phase III) is already available on the SIDBI website, most of the industry associations and unit owners are unaware of this list[29].

Also, the purchase made for energy efficiency equipment doesn't mandate purchase of highly efficient equipment, for example units who may have gone ahead for replacement of inefficient/old motors by better models have simply raised purchase order for new motors but many POs do not have high energy efficiency rating as a selection criteria.

Solutions:

Provide support to the MSME units for easy access to information about energy efficient equipment and their suppliers.

Activities:

1. **Mobile based app for list of equipment and service suppliers:**

   - A technology based suggestion for promoting EE can be introduction of a mobile based application where the unit owners are immediately able to see on their mobile a list of suppliers for the required energy efficient equipment.

   - The app can provide details of equipment, technology and service providers as follows:

     - Local vendors – for quick support
     - National vendors – for better efficiency and choice
     - International vendors – for new, innovative state of the art technologies implemented across the world

     Depending upon the choice of the unit owners keeping in mind the cost, significance and availability of the equipment, they can choose from the list of

[29] Energy Saving Equipment List (ESEL) Release 9.1, Prepared for SIDBI, Supported by JICA - https://www.sidbi.in/downloads/Energy%20Saving%20Equipment%20List_9.1.pdf

vendors. This will help the units and cluster associations to get access to both national and international suppliers and vendors.

The scheme proposed above can also include building the application and training a team in the Office of DCMSME which will regularly maintain and update the application.

2. Through various existing programs, the government can arrange for implementing pilot projects across the clusters (where the need arises) that use innovative and advanced international technology to support technology improvement and reduction in fuel consumption and emissions.

Outcome:

Easy access to some energy efficient equipment and their list of suppliers for quick replacement of equipment in case of failures.

Recommendation 2: Optimal utilization of resources available with MSME Tool Rooms & Training Centres and other similar institutions

Challenges:

To meet the growing demand of Tools and dies in the country, particularly in the MSME sector, GOI decided to assist setting up of Tool Rooms and Training Centres across the country. The tool rooms generate a work force of skilled workers, supervisors, engineers/designers etc.

Stability of manpower is a major problem in many clusters and most of the hired manpower is unskilled and trained on the job. Still, skilled manpower from the MSME tool rooms and other training centres like it is etc. are not utilized by these clusters. For example, though Faridabad is one of the biggest cluster in India and requires high number of skilled operators, it seldom hires manpower from the Training Centre in Okhla, Delhi.

Further, most of the unit owners are not keen on providing their operators with trainings on specialized skills as the trained manpower then demands higher compensation or is easily poached by other units.

Solutions:

A better collaboration among the training institutions and local MSME clusters needs to be put into practice where the skilled / trained operator gets absorbed in the SME industry and the ultimate object of the GOI for setting up Tool Rooms and Training Centres is achieved.

Activities:

1. A module on Energy and Environment can be introduced in the existing courses at the MSME Tool Rooms and other training centres to equip the skilled workers, supervisors, engineers/designers about the different technologies available to save energy and also the various environmental compliances required by the units.

2. Under the MoMSME scheme of setting up Tool Rooms and Training Centres, it can be ensured that the financial assistance for setting up new Tool Rooms is given to states/state agencies such that their location is aligned with the requirement from the surrounding nearby clusters.

3. Spread awareness about the different training centres and the skills in which the operators are trained through:

    - Organizing events for the nearby clusters to promote offtake of the skilled operators, engineers and designers

    - Associating with cluster associations to display information about the training centres (skills in which the people are trained, course curriculum, no. of operators, engineers and designers being trained, finishing date of the course, brief profile of the operators etc.) on their websites.

    - Collaborate with cluster associations to participate/present in their annual/bi-annual meetings (when most unit owners attend) to spread information and gain familiarity within the clusters.

    - GOI can provide financial assistance to the Small Industries Development Organization (SIDO) to organize workshops in large clusters located near the existing tool rooms educating them about the benefits of hiring skilled operators.

Outcome:

Hiring skilled workers would help the units in better and efficient utilization of existing systems that would in turn improve the efficiency of the system.

Recommendation 3: Enhance role of cluster associations

Role of cluster association can be enhanced as they are one of the agencies who remain in close contact with the SME unit owners most of the time.

Challenges:

After discussions with the unit owners and cluster associations, it was found that the units where energy audits were performed and energy efficient technologies were implemented were not always too keen in sharing the benefits with their rivals/competing units in the same field. The units were not sharing the technological benefits in their internal association meetings which would have nudged other units. This was one of the major reasons for failure of earlier dissemination programmes as replication of good practices/energy efficient technologies could not happen on a larger scale.

Further, the capacity building workshops that have been organized in the clusters are sometime repetitive, time intensive & not aligned with the capacity needs of units.

Solutions:

Most of the workshops that were repetitive can be restructured to a more effective and participatory format. For a mixed cluster like Faridabad with numerous industries segments, industry and technology specific workshops can be organised.

Activities:

1. Cluster associations shall promote new EE & RE technologies by mandatorily sharing best practices and results of piloted energy efficient and innovative technologies (at least the ones organized in the future under various programs that involve government institutions like SIDBI, BEE, MoMSME etc.) in the cluster with all the unit owners.

2. Industry Associations may be designated to support in the monitoring and reporting of implementation and compliance process for all the units audited in a cluster.

3. Cluster associations can organize industry and technology specific workshops in the clusters which can be more effective and participatory by streamlining them according to the needs of industrialists to ensure better participation and adoption of interventions.

4. International experts from other developed countries can be invited by the cluster associations for knowledge dissemination on use of innovative technologies and ways to improve the existing technology used for better production and fuel efficiency. For some of these workshops, funding can be availed from the NMCP Scheme for 'Technology and Quality Upgradation (TEQUP) Support to MSMEs'.

Outcome:

- Better replication and outreach of energy audits performed in the clusters under existing programs.

- Effective knowledge dissemination among the stakeholders.

Recommendation 4: Setting up of high quality motor rewinding centres

Challenges:

Motors are one of the basic equipment that can be found in almost all industries. One of the common causes of motor damage is overloading and thus burning of the windings. This is very common in MSME units as no protection devices are installed in the electrical system. Repairing or rewinding can help the owners lower operating costs, improve motor reliability and uptime and improve return on investment.

Rewinding an electric motor is delicate and professional care is needed. Though there are some professional companies that perform high efficiency motor rewound in India, most of the SME units do not approach them and get low quality rewinding done locally through self-trained technicians. Though the repaired motor is returned in a short time, the efficiency of the equipment reduces drastically.

Activities:

1. **Set up Motor Rewind Centres:**
    - The GOI can introduce a scheme through MoMSME to provide financial assistance for setting up of high quality motor rewound centres near large clusters.
    - These centres will rewind used motors to a specified high level of efficiency.
    - Skilled professionals trained in rewinding motors will be hired to do the job. Technicians trained from MSME Tool Room and Training Centres can also be hired if they meet the criteria.
    - The efficiency of the rewound motor would be checked and a certificate would be issued by the Motor Rewind Centre stating the efficiency of the rewound motor.
    - MoMSME can provide partial funding for this activity to the cluster associations who would be responsible for setting up and managing these centres.
2. Spread knowledge through workshops and seminars about motor protection and the devices that should be installed to avoid motor overloading.

Outcome:

Local and fast support for high quality energy efficient rewinding of motors.

Conclusion

As seen in the previous chapters, MoMSME has introduced a number of schemes in the past for promoting and financing energy efficient technologies. Still, the SME unit owners are faced with challenges like inadequate skills, unavailability of time, lack of decision making ability and initial financial cost constraints. Through the recommendations listed above, possible solutions have been provided for some of the problems and barriers faced by the manufacturers and unit owners at the ground level. If, on one hand, unit owners have quick access to energy efficient equipment and on the other hand, have trained and skilled operators, energy efficiency proliferation in the sector will become relatively easy. Also, stronger cluster associations will be able to better understand and meet the needs of the units. This will in turn help in creating an enabling environment which will accelerate adoption of EE technologies proposed in the previous chapters and help in achieving the low carbon pathways by 2025.

Annexure 1 – Project Workshop

A final project workshop was organized in association with Shakti Foundation on 'Developing an Energy Efficiency Strategy for Small & Medium Enterprises in India' on the 13th of January 2017 at the Shangri-La's Eros Hotel, New Delhi.

The workshop included around 20 participants from eminent organizations with ample experience of working in the MSME sector like SIDBI, TERI, CEEW, UNIDO, Stentum Asia, Foundation of MSME clusters, IamSME of India and a few SME unit owners. A number of topics like challenges faced by the units in adoption of energy efficient technologies, development of energy consumption baseline for the SME sector, impact assessment of energy efficient technologies on the MSME sector and developing an energy efficiency strategy to increase the penetration of such technologies at the ground level were discussed in detail. Due to the selected limited audience, a very interactive discussion could be held within the group to discuss on the various topics and assimilate the suggestions from the industry experts.

Feedback

The following feedback was received from the participants:

- The MSME schemes and programs should be designed in a way such that all the stakeholders come together at the same time and there is overlapping of time between different agencies working on consecutive components of the program.

- The detailed list of equipment suppliers prepared under the JICA-SIDBI MSME Energy Saving Project (Phase III) is already available on the SIDBI website and should be promoted at the industry association and unit level to support the owners in purchase of energy efficient equipment.

- It was pointed out that as a large percentage of energy audits conducted in the MSME units were free and not paid by the units, the seriousness of adapting to the new technology and replicating it within the cluster was low.

- As the calculation in the Decision Support Tool considers a period of 9 years from 2016 till 2025 for the implementation of energy efficient technologies, it was suggested to take into account the effect of country's GDP growth rate over the same period.

- It was suggested that depreciation of the energy efficient equipment from the year of implementation can be taken into account.

- A factor related to depreciation or appreciation of the Indian currency over the period of implementation can be considered in the calculation.

- As for the electrical energy, it was suggested to include a single price of thermal energy (INR/toe) in the calculations. Also, the source of "price per toe" value for various interventions considered in the study can be mentioned in the report.

- Most of the energy efficient interventions selected in the study are cross-cutting in nature and only a few are process specific interventions. It was suggested that if more interventions are included in the calculations, the total energy savings would increase further, which should ideally happen in this case.

- It was suggested that changes in the operational procedures and behaviours (for e.g. efficient utilization of day-light etc.) can also save energy to a large extent. These savings however are not accounted for in the calculations.

- It was suggested that the implementation of each intervention can be staggered over a period of 2 to 3 years rather than implementing each intervention in a single year.

- Against the suggestion of building warehouses near large clusters to store high turnover energy efficient equipment, it was suggested that stocking the equipment was not a good idea. Wherever such a requirement would arise, the market forces will come into action. Proving subsidy for such a recommendation is not a long term solution.

- It was also pointed out that many equipment come with a warranty date that starts from the date of manufacture of the equipment. No unit owner would prefer buying equipment purchased beforehand with a lower warranty period.

- Against the suggestion of setting up motor rewinding centres, it was pointed out that the success of such services is only possible if the price is comparable with the rewinding done by local technicians.

- The major reason for failure of motors in the MSME industries was found as lack of installation of protection devices to protect the motors from conditions like overloading, over-voltage etc. It was suggested to increase awareness and promotion of such protection devices to increase their adoption in the industry.

- Rather than setting up fixed motor rewinding centres in major clusters, it was suggested to explore the option of mobile motor rewinding vans/trucks to provide local support and reach wider audience.

- It was pointed out that the offtake of trained operators and skilled manpower for utilization in the MSME units should not just be limited to MSME tool rooms and training centres. Other institutions providing similar skills and trainings like ITIs, polytechnics etc. should also be included.

- It was informed that in many cases, the unit owner does not want its staff to be trained in a specific skill as it leads to the trained staff demanding higher salaries or getting poached by other units. This issue also needs to be looked into.

- It was suggested that the cluster associations should not be given the task of monitoring and verification of the energy audits under the MSME programs as they do not have the required staff to undertake the activity. However, since the associations are in regular contact with the units, they can be involved in the activity in a larger capacity than before and assist the hired agency to smoothly finish the M&V.

List of Participants

The following participants attended the workshop:

1. Rajat Batra, Stenum Asia
2. Tirtha Biswas, Council on Energy, Environment & Water
3. Sanchit Waray, Council on Energy, Environment & Water
4. Girish Sethi, TERI
5. Sudhir Kumar Singh, UNIDO
6. Pawan Kumar Bharti, SIDBI
7. Karthik Ganesan, Council on Energy, Environment & Water
8. Niranjan Rao Deevela, UNIDO
9. Shankar Haldar, SIDBI
10. Vishal Dev, Foundation of MSME clusters
11. Gaurav Kumar Rai, IamSME of India
12. Dishant Badlani, Prayag Clay Products Pvt. Ltd.
13. Rana Pujari, Shakti Sustainable Energy Foundation
14. Shubhashis Dey, Shakti Sustainable Energy Foundation
15. Charu Lata, EY
16. Rahul Gupta, EY
17. Anindya Bhattacharya, EY
18. Shuvendu Bose, EY

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