Alliance for an Energy Efficient Economy

Sustainability Outlook

SHAKTI SUSTAINABLE ENERGY FOUNDATION

PAT Pulse

Tracking the Perform-Achieve-Trade Scheme for Energy Efficiency

May 2016

Rs 34,000 CRORE ENERGY EFFICIENCY INVESTMENT OPPORTUNITY AWAITS INDIAN INDUSTRY

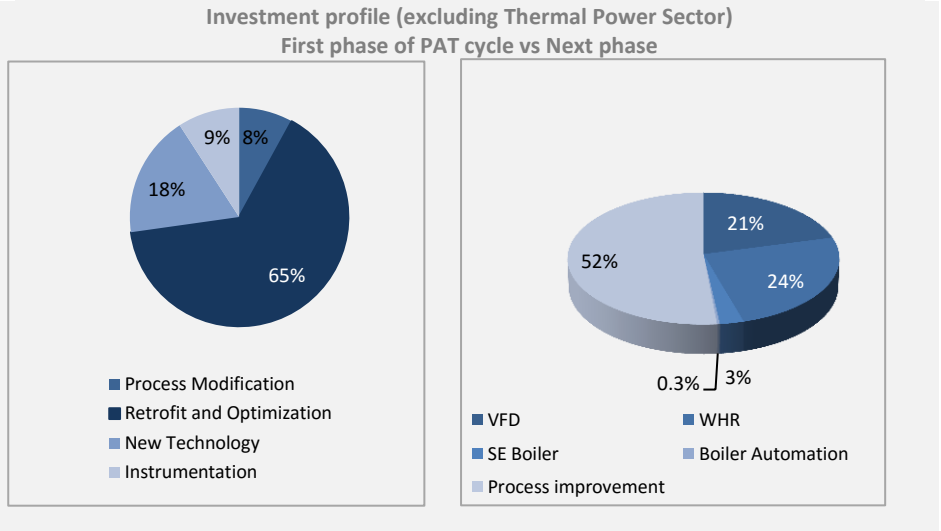
Achieving energy efficiency in industries is a priority for India from the perspective of cost savings as well as climate change. The Perform-Achieve-Trade (PAT) scheme was formulated to achieve this objective by facilitating a market based mechanism for promoting energy efficiency.

'PAT Pulse' is a quarterly briefing series on PAT with DCs, policy makers, catalysts and industry experts to capture the pulse of the energy efficiency market in India created by Sustainability Outlook and Alliance for Energy Efficient Economy (AEEE) in collaboration with Shakti Sustainable Energy Foundation. The objective of this stakeholder briefing series is to provide evidence based, market assessment tool to present the stakeholder view point, enable higher uptake of PAT through peer learning and incubate industry and policy action on energy efficiency.

In this brief

Sizing the investment opportunity for the next 4 years- focus will be on process improvements

In the January 2016 issue of PAT Pulse we assessed the types of projects that were undertaken by Designated consumers (DCs) in Phase 1. We found that almost 60% of projects carried out were relevant across sectors (and not sector specific) and were characterized by low capital investment and small payback period. In this PAT Pulse brief we find that as the industry moves to the next PAT cycle, the trend of investment will switch from cross-sectoral techniques and the focus will tilt towards process improvements. These industry specific investments are likely to now account for more than **50%** of the potential investments in energy efficiency.



Sustainability Outlook and AEEE created a detailed bottom-up model to assess the investment opportunity, the findings of which are presented in this issue of PAT Pulse.

Policy updates

The issue also provides updates policy regarding terms and Conditions for Exchange of Energy Savings Certificates and the roles of multiple entities associated with the trading.

Innovations

It also provides a sneak peek into some of the upcoming innovative solutions such as IoT (Internet of Things) driven lighting and process automation, coating process for textiles, power converters and CO2 recovery solutions.

Rs 34,000 CRORE ENERGY EFFICIENCY INVESTMENT OPPORTUNITY AWAITS INDIAN INDUSTRY

Highlights:

- Industrial Energy efficiency is Rs 34,000 crore market with cross sectoral interventions such as VFD, WHR accounting for 21% and 24% of the estimated investment potential respectively and key sectoral BATs accounting for 52%.
- Chlor Alkali (95%) and Aluminium (74%) sectors have the maximum percentage of the total sectoral investment potential in process linked interventions while textile (5%) has the least.
- Enhanced technical competencies of service providers, Need for market making mechanism Robust ESCO financing models are ingredients for faster scaling up of energy efficiency investments

Energy efficiency has cemented its place as the "first fuel"

In a world where policy makers increasingly have to pave development paths tailored to national priorities for combating Climate Change while at the same time ensuring robust economic activity, the importance of Energy efficiency couldn't be highlighted more. Technology interventions for energy efficiency have a significant role in creating least-cost pathways for meeting climate policy goals.

As an illustration of the substantial impact of energy efficiency, in the IEA member countries, investment in energy efficiency from 2005 until 2010 resulted in cumulative avoided energy consumption of 570 million tonnes of oil-equivalent (Mtoe). Without these energy efficiency measures, 5% more energy would have been consumed by the 11 countries during that period.

In the year 2014, the International Energy Agency (IEA)[1], provided estimates of the "probable magnitude" of energy efficiency market which pegged it at greater than **300 Billion USD.**

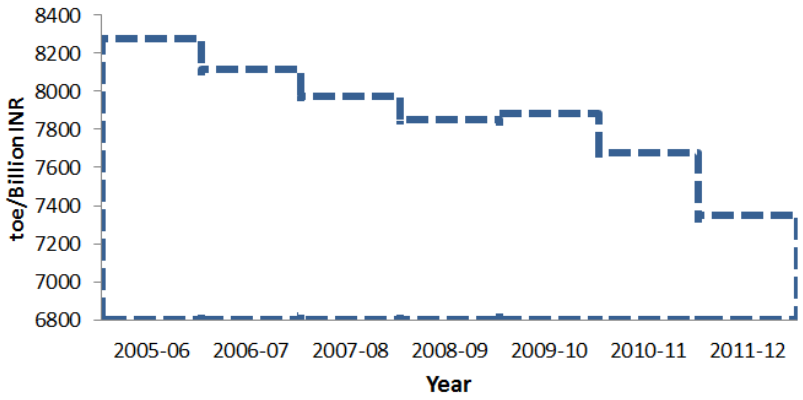
The Intended Nationally Determined Contribution (INDC) target committed by India at COP 21 in Paris to reduce its emissions intensity by 33-35 percent from 2005 levels by 2030 would require energy efficiency investments to be a major driver on the demand side. Energy demand in India is expected to grow at Compounded Annual Growth Rate (CAGR) of nearly 4 percent by 2030 (from 2013)[2]. Finding adequate supplies of energy to satisfy this increased demand is a significant challenge.

India industry has scope for improvement on Specific Energy Consumption compared to the global average

At the national level, energy intensity is often expressed as metric tons of oil equivalent per unit of Gross domestic product. The energy intensity of India's GDP in Manufacturing has been presented in Figure 1which shows that Indian manufacturing is steadily becoming less energy intensive.

[1] Energy efficiency Market Sizing Report, 2014, IEA
[2] India Energy Outlook, World Energy Outlook Special Report 2015, IEA

Figure 1: Energy Intensity of Manufacturing GDP – India

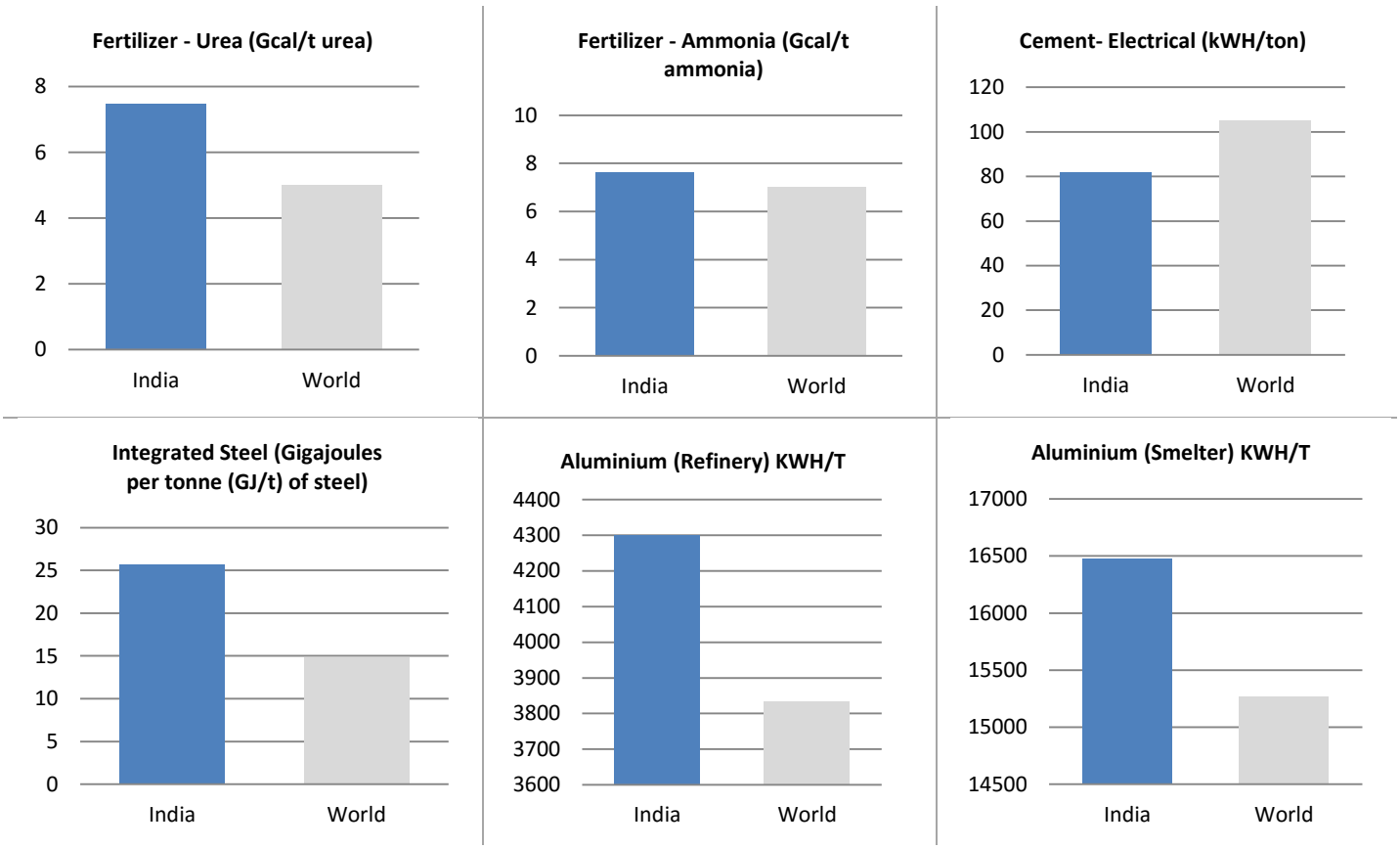


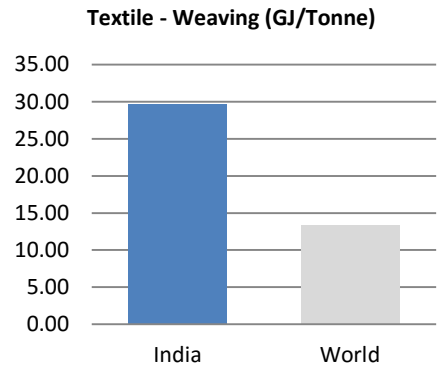
Source: Sustainability Outlook estimates compiled from Handbook of Statistics (RBI), International Energy Agency (IEA)

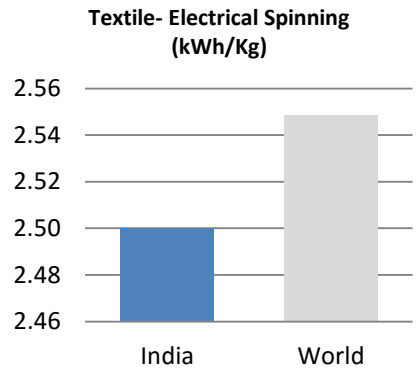
If we compare the average Specific Energy Consumption (SEC) of Indian companies with the current global best (Figure 2), it can be seen that the Indian firms still have scope for efficiency improvement apart from a few sectors such as cement with Indian manufacturing units are ahead. Sectors such as paper and pulp, aluminium, iron and steel have significant ground to cover in order to compete with the global best in terms of SEC.

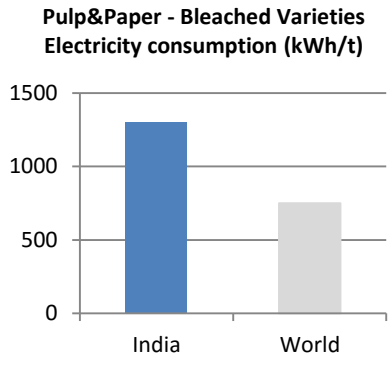
Informed policy making would entail setting prudent and achievable targets for energy efficiency interventions, and tracking the progress against those targets, which necessitate an understanding of the true potential of Energy efficiency markets.

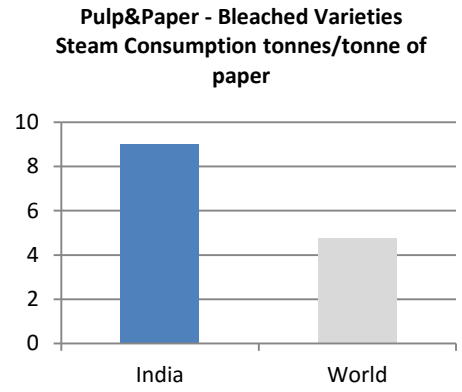
Figure 2: Specific Energy Consumption – India average vs Global best

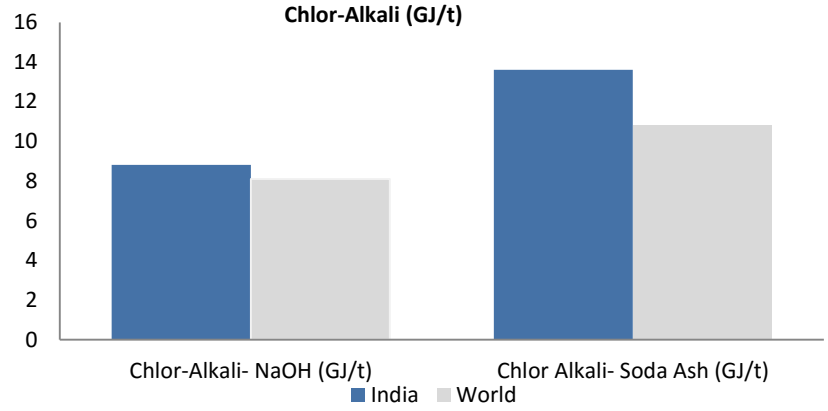












As is evident from above, there exists a significant potential for industrial energy efficiency improvements in India. In order to quantify this in a meaningful and actionable manner, Sustainabiliy Outlook and AEEE have created a detailed model to size the investment potential of energy efficiency interventions across various PAT sectors (excluding thermal power sector).

Although energy efficiency **market sizing studies with specific focus on India** have been carried out in the past, their estimates have been found to have a high variation which presents a need for improved, data-driven market valuations.

- **2008**: A study by World Bank estimated the energy savings potential in India, China and Brazil to be around 50 billion kWh for which investment potential was calculated to be **INR 14,000 Crores (~USD 2 billion)[3].**
- **2009: A report prepared by WRI titled "Powering up"** indicated that the industrial sector including small, medium and large enterprises, offers a good opportunity to save 49 billion kWh of energy per year, with an investment potential of **USD 3 billion (Rs 19,500 crores)**. (The estimate is for Investment potential of ESCOs in India)
- **A study done by the Confederation of Indian Industry (CII)/Indian Renewable Energy Development Agency (IREDA)** indicates that estimated annual savings potential is around INR 3,750 crores and investment potential for energy efficiency is about **INR 8,250 crores** in India.
- **2010**: **BEE** had estimated the total Energy efficiency market size in India to be **USD 18 Billion.** It was also estimated that by mandating all large **Government buildings** (approximately 8000 in number) to undertake energy efficiency measures**,** an investment potential of **USD 2 billion** could be unlocked in 3 years[4].
- **2016**: The **Bureau of Energy Efficiency** prepared its estimates for Energy Efficiency investments in the first cycle of PAT which were **US$ 3095 million (~Rs 20,000 crores)[5].**

[3] Assumption: 1 USD = Rs 65

[4] A Market for Energy Efficiency in India -Presentation by Saurabh Kumar Secretary, Bureau of Energy Efficiency : International Symposium on New Paradigms for Energy Policy and Regulation, 8th January 2010

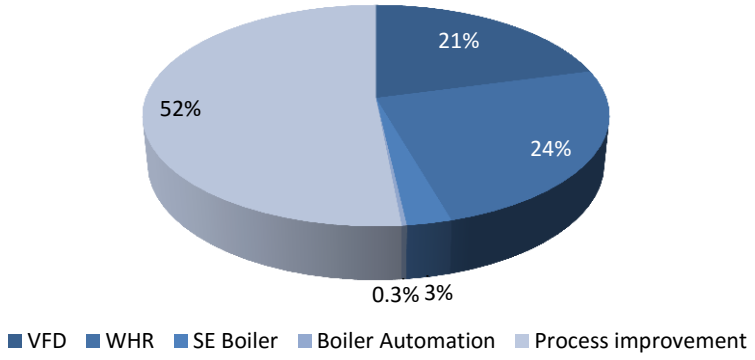
[5] Stakeholder Consultative Workshop for Promotion of Resource Efficient Textile Manufacturing in Bangladesh 25th March,2016

Industrial Energy Efficiency: INR 34,000crore market opportunity by 2020 (excluding Thermal Power Sector)

Sustainability Outlook and AEEE estimate the potential of industrial energy efficiency interventions for the DCs across the PAT sectors (excluding thermal power sector) to be **Rs 34,000 crores (~USD5 billion)** which is likely to be realized by 2020.

Cross cutting technologies such as Variable Frequency Drives (VFD) and Waste Heat Recovery (WHR) Systems account for 21% and 24% of the estimated investment potential respectively, with the majority share (52%) being held by sector specific process innovation techniques.

Figure 3: Rs 34,000 crore Industrial EE market by 2020 (excluding thermal power sector)



Source: Sustainability Outlook – AEEE analysis

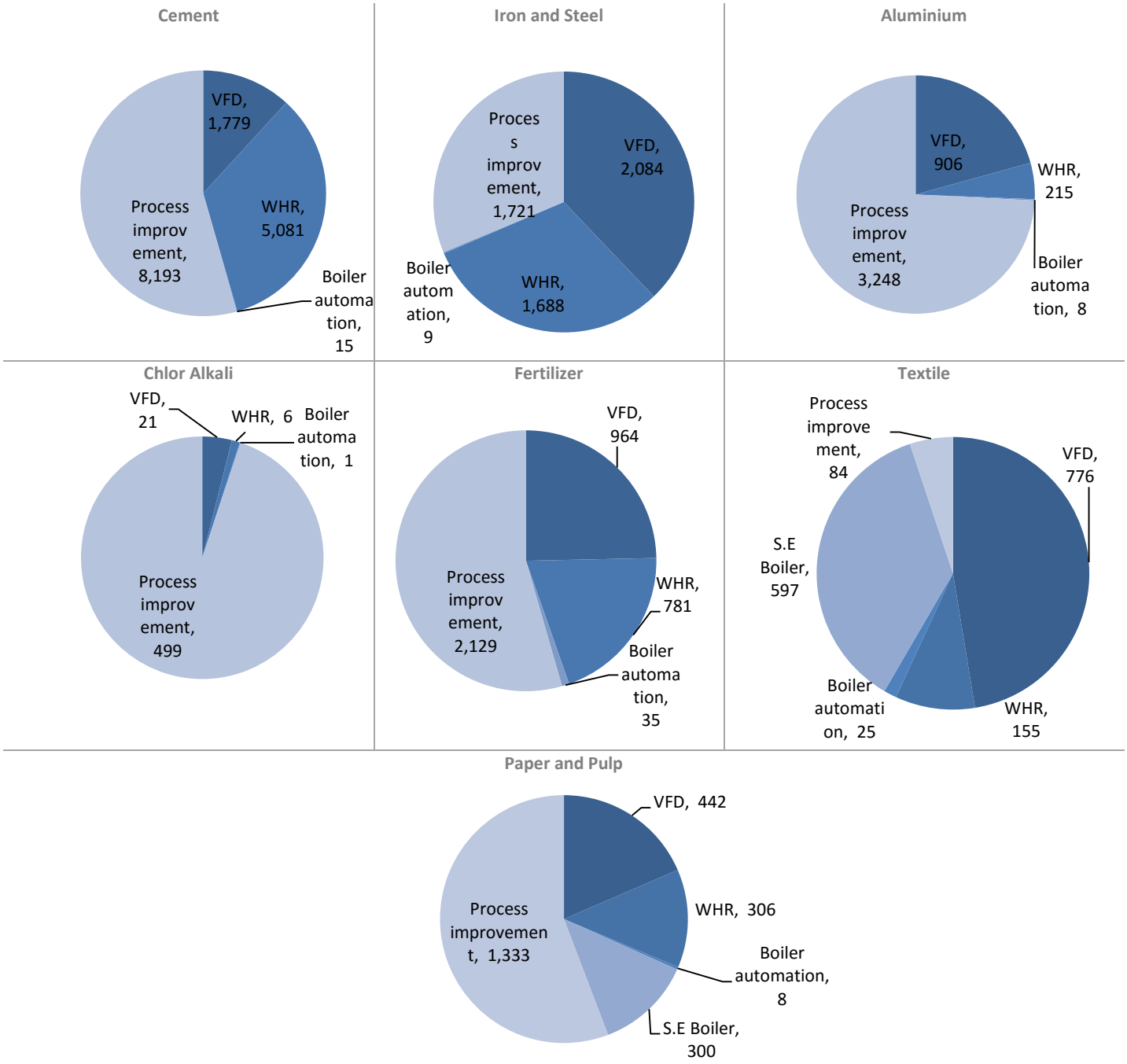
For the purpose of this study, a bottom-up approach was followed for estimation of investment potential of energy efficiency interventions for Designated Consumers (DCs) under the PAT scheme. Detailed list of Best Practices and Innovative energy efficiency interventions was created for each of the PAT sectors (excluding thermal power sector). Technical Experts were consulted to estimate the applicability and the current level of penetration of these technologies, using which the unexplored potential i.e, the investment opportunity size was calculated.

It was gathered through stakeholder consultations that certain interventions would be cross-sectoral and are likely to be amongst the thrust areas for multiple sectors under the upcoming phase of the PAT scheme. It was gathered that technologies such as Variable Frequency Drives (VFD), Waste Heat Recovery (WHR) Systems, Super-efficient process boilers and Automation and Control Systems for boilers would have a key role to play in the second phase of the PAT scheme. Therefore, the market sizes of the above mentioned technologies across the PAT sectors have been estimated separately.

Apart from these cross cutting generic technologies, insights on sector specific technologies linked to process improvement with potential for high impact were gathered through discussions with Sector experts and Accredited Energy Auditors. The market for such key technologies has also been estimated for the Cement, Chlor Alkali, Pulp and Paper, Iron and Steel, Textile, Fertilizer and Aluminium sector. Figure 4 highlights the sector wise investment potential across cross cutting interventions and process improvements.

In the coming 3-4 years, Chlor Alkali (95%) and Aluminium (74%) sectors have the maximum percentage of the total sectoral investment potential in process linked interventions. On the other hand, textile has the least percentage (5%) of total sectoral opportunity being driven by process, with the rest 95% coming from cross cutting applications such as VFD, WHR and super-efficient boilers. Iron and Steel and Cement sectors present a balanced portfolio of potential between process improvement linked interventions and cross-sectoral ones.

Figure 4: Sector wise investment potential (Rs crores)



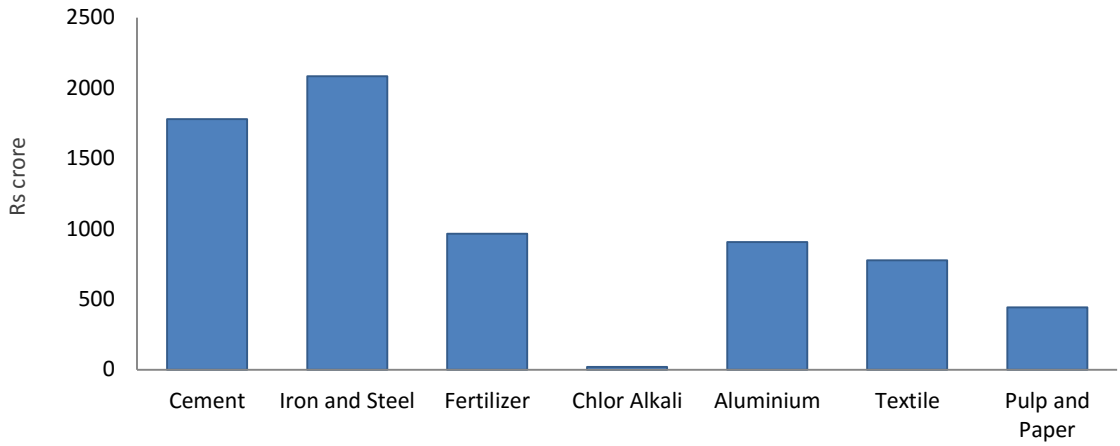
Source: Sustainability Outlook – AEEE analysis

Potential market of Rs 7,000 crore for Variable Frequency Drives across sectors

Variable Frequency Drives (VFD) for motor systems present a significant opportunity for energy consumption reduction across the PAT sectors - which is now well-recognized by the industry as well. Although VFD as the go-to option for reducing energy consumption in motive loads has been around for a while, **it had seen limited adoption when the technology was nascent due to high risk perception.** Not surprisingly, the industry experts consulted during this study are of the opinion that there is still a huge untapped potential for VFDs in the Indian industry.

Sectors including Iron and Steel, Cement, Aluminum and Fertilizer have a sizable potential for this application. As per the views of multiple stakeholders, including DCs, Energy Auditors and other industry experts, VFDs are likely to see strong uptake across manufacturing units and be one of the early target interventions under the 2nd cycle of PAT.

Figure 5: VFD Market Potential for PAT sectors



Source: Sustainability Outlook – AEEE analysis

VFDs primarily have two **main market segments**, namely **High Tension drives (HT) and Low Tension drives (LT)**, with the former having a relatively higher potential in the Indian industry and being more efficient in terms of **savings per unit investment**. Both the segments have seen varying penetration rates in the Indian Industry with the uptake of LT drives being relatively higher than that of the HT drives. This is because, while on the one hand there the **upfront capex for LT drives Rs.6000-7000/kW and simple payback is <2 years** the **capex for HT drives is Rs.15000-20000/kW and the associated payback period is 3-4 years**. Furthermore, the costs of LT drives have fallen in the past decade but the costs of HT drives haven't seen a similar drop.

For the purpose of this study, the values for electrical consumption in kWh were estimated based on the industry averages for thermal and electrical energy consumption and the quantum of motive load consumption was derived out of the same. Furthermore, additional filter of the applicability of VFDs within the Motive Load consumption and their current penetration was applied to estimate the remaining investment potential for this technology.

Cement and Iron and Steel to lead the Rs 8,000 crore Waste Heat Recovery Market

Waste heat losses arise both from equipment inefficiencies and from thermodynamic limitations on equipment and processes. Industrial waste heat can either be reused within the same process or transferred to another process. Waste Heat recovery (WHR) systems have 3 main market segments in India namely:

- High temperature WHR for power generation
- Low Temperature WHR for power generation
- Low Temperature WHR for process integration

High temperature WHR: 1,200ºF [**649**ºC] and higher
Medium temperature WHR: 450ºF [**232ºC**] to 1,200ºF [**650ºC**]
Low temperature WHR: 450ºF [**232ºC**] and lower

Table 1 lists technologies which can be potentially used for heat recovery in the industrial sectors as per the grade of heat available.

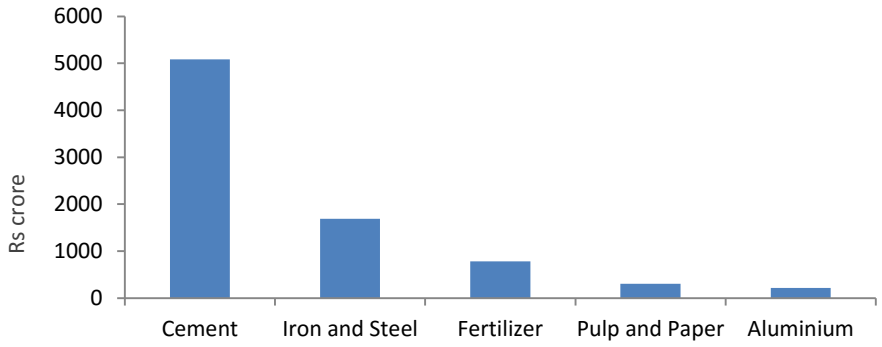
Table 1: Grades of Heat recovery and corresponding technologies

High Temperature heat recovery technologies	Medium Temperature heat recovery technologies	Low Temperature heat recovery technologies
Thermo-chemical reaction recuperators	Recuperators with innovative heat transfer surface geometries	Convection recuperator (metallic) of many different designs
Recuperators with innovative heat transfer surface geometries	Advanced design of metallic heat wheel type regenerators	Advanced heat pipe exchanger
Advanced design of metallic heat wheel type regenerators	Self-recuperative burners	Membrane type systems for latent heat recovery from water vapour
Self-recuperative burners	Systems with phase change material	Low temperature power generation (i.e., ORC, Kalina cycle, etc.)
Systems with phase change material	Advanced heat pipe exchanger	Thermally activated absorption systems for cooling and refrigeration
Advanced load or charge preheating systems		

Source: Industrial Waste Heat Recovery: Potential Applications, Available Technologies and Crosscutting R&D Opportunities - Oak Ridge National Laboratory

As per our estimates based on percentage of recoverable waste heat (sector-wise) and its usability potential, the waste heat recovery systems have an investment potential of approx. **Rs 8,000 crores across the 7 PAT sectors** (excluding thermal power sector)

Figure 6: Sector wise Investment Potential of WHR technologies - All grades



Source: Sustainability Outlook – AEEE analysis

Source: Industrial Waste Heat Recovery: Potential Applications, Available Technologies and Crosscutting R&D Opportunities - Oak Ridge National Laboratory

High Temperature WHR systems based on Rankine cycle have a **high potential in the Iron and Steel and Cement sectors** in India as can be observed in Figure 6, whereas sectors such as **Pulp & Paper** have **relatively low potential**. Based on our estimates, the potential for High grade waste heat recovery in the Cement sector alone is around 630 MW, with the present operational capacity estimated to be around 120 MW.

Low Temperature WHR systems by way of Process Integration are **more economical** (payback of 6 months-2 years) **than WHR systems for Power Generation** (payback of 3-8 years). The former combination has **potential in the fertilizer and textile sectors**.

However, the **true extent of the potential for low grade waste heat recovery by way of process integration is not known** as no specific studies in that direction have been carried out by BEE or Energy Auditors. **However, few industries are in the preliminary stage of carrying out such process modifications in the Fertilizer and Refinery sectors**.

Factors influencing the business case for Waste Heat Recovery include:

- Quantum and efficiency of power Generation from the installed WHR system
- Commitment by supplier regarding payback of the recovery system
- Design innovation by supplier which will impact efficiency levels

Process Integration means combining Needs/Tasks of "**opposite**" kinds so that **Savings** (or Synergies) can be obtained [6]
Examples of such Integration in the Process Industries:

- ***Heat*** Integration
  - Cooling & Condensation integrated with Heating & Evaporation
  - Identify near-optimal Level of Heat Recovery
  - Design the corresponding Heat Exchanger Network
- ***Power*** Integration
  - Expansion integrated with Compression
  - Same Shaft or combined in "Compander"
- ***Chemical*** Integration
  - By products from one Plant used as Raw Materials in other Plants
  - The Idea of materials integration is used in Industrial "Clusters"
- ***Equipment*** Integration
  - Multiple Phenomena (Reaction, Separation, Heat Transfer) are integrated in the same piece of Equipment
  - Process Intensification

Policy has incentivized adoption of WHR in Industry

States such as Rajasthan[7] had considered that electricity produced through Cogeneration (irrespective of the fuel used for such Cogeneration) and waste heat recovery shall be qualified as Renewable energy for the purpose of RPO compliance (as per order dated 7th March 2007) which saw a significant uptake of WHR especially in cement plants in the state. However, a revised order in March 2014 has reversed that stance and now electricity produced from fossil fuel based co-generation will not be considered as Renewable Energy for the purpose of meeting their RPO obligations. Tamil Nadu and UP also recognize WHR as a renewable energy, thus making it eligible for REC. However, since dual benefits of REC and ESCerts (benefit under PAT scheme) cannot be availed unless the Electricity Act is amended these state policies are unlikely to influence the adoption of WHR under the PAT scheme.

Separately, under the Corporate Responsibility for Environmental Protection (CREP) guidelines issued by Central Pollution Control Board[8], all Sponge Iron Plants of capacity more than 100 TPD kilns shall install Waste Heat Recovery Boiler (WHRB) for power generation.

[6] Truls Gundersen, Department of Energy and Process Engineering, Norwegian University of Science and Technology (NTNU) Trondheim, Norway
[7] http://rerc.rajasthan.gov.in/cnpl/PDFs/REC.pdf
[8] http://www.cpcb.nic.in/divisionsofheadoffice/pci2/CREPspong&other.pdf

Table 2 highlights some of the key areas of recovering waste heat from different processes/equipment across multiple sectors as per the temperature category.

Table 2: Avenues for Waste Heat Recovery in Industrial Sectors

Industry Sector	Sources of Waste heat	Temperature (Degrees C)	Type of Waste Heat Recovery - Low /medium/High Temp
Iron and Steel	Steel electric arc furnace	1,370-1,650	High Temp
Iron and Steel	Basic oxygen furnace	1,200	High Temp
Iron and Steel	Steel heating furnace	930-1,040	High Temp
Iron and Steel	Coke oven	650-1,000	High Temp
Iron and Steel	Blast Furnace - BF Gas		High Temp
Iron and Steel	Blast Furnace- Hot Blast Stove Exhaust		High Temp
Iron and Steel	Iron cupola	820-980	High Temp
Iron and Steel	BF Slag	1300°C	High Temp
Iron and Steel	BOF Slag	1500°C	High Temp
Iron and Steel	Hot Coke	1100°C	High Temp
Iron and Steel	Cooling water from Ingot Casting	60	Low Temp
Iron and Steel	Cooliing water from Electric Arc Furnace	95	Low Temp
Iron and Steel	Cooling water from Heating Furnaces	100	Low Temp
Cement	Cement kiln - Wet Kiln	338	Medium Temp
Cement	Cement kiln - Dry Kiln	450-620	Medium Temp
Aluminium	Hall Heroult Cells	700	High Temp
Aluminium	Melting Furnaces	1,150	High Temp
Aluminium	Stack Melter	121	Low Temp
Aluminium	Calciner exhaust gases	180-200	Low Temp
Aluminium	Products of combustion from anode baking operations	200-316	Low Temp
Cross Cutting	Steam Boiler	260	Low Temp
Pulp and Paper	Exhaust air from paper machine dryers	60-82	Low Temp

Source: Electricity generation from low temperature industrial excess heat – an opportunity for the steel industry Maria T Johanssona,Mats Söderström

Technology is not the key issue in WHR

Lack of technology options and suppliers is not the primary reason for low adoption of waste heat recovery in the Indian industry. Indian waste heat recovery boiler (WHRB) manufacturers have been able to well adapt international technology and customize it to suit Indian conditions. It is believed that Indian technology suppliers have adequate technical know- how for waste heat recovery across industrial sectors and most of material/equipment for WHRB are available locally apart from some boiler quality plates, special alloy steels and fin tubes which are currently imported.[9]

As regards low grade WHR systems, the technology suppliers are primarily from Israel and Sweden and there is a relative shortage of Indian suppliers, as a result of which the costs of such technologies are on the higher side

Different types of WHRBs supplied for different applications by Indian manufacturers

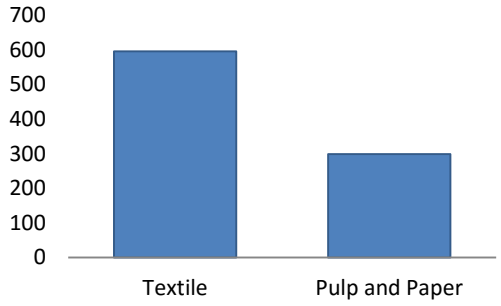
- Gas turbine exhaust gas WHB
- Blast furnace gas WHB
- Carbon monoxide fired WHB
- Cracker off gas WHB
- Diesel generator exhaust gas WHB
- Hydrogen gas fired WHB
- Incinerator off gas fired WHB
- Nitrous gas WHB
- Reformed gas WHB
- Synthesis gas WHB

[9] http://www.dsir.gov.in/reports/techreps/tsr117.pdf

Textile and Paper and Pulp sectors have significant market Potential of Super Efficient Boilers for Process Heating

Super-efficient boilers are a priority area for process industries such as textile and paper and pulp sector which need steam for process heating. Focussing on these two sectors only, t**he overall market for super-efficient boilers which is realizable by 2020 has been estimated to be Rs 900 crores with textile sector accounting for 67% of the total estimate** (Figure 7).

Figure 7: Investment Potential Super Efficient Boilers - Rs 900 Crores

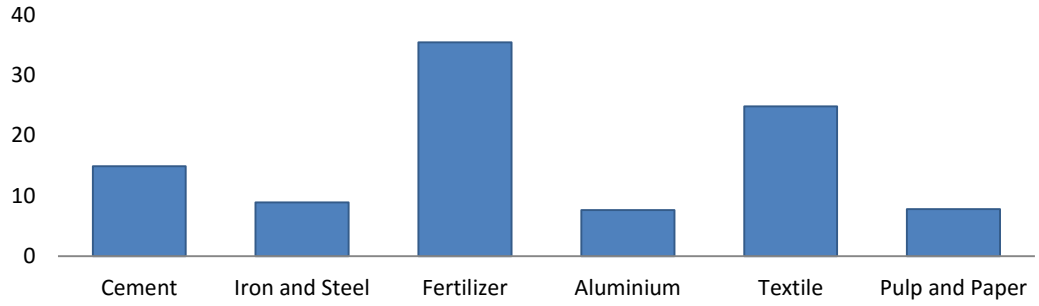


Installation of new process boilers (with high thermal efficiency) is generally carried out corresponding to an increase in the production capacity as it entails high investment costs. Therefore, for the purpose of this study, the market for super-efficient boilers has been estimated only for the new production capacity that is expected to come up between 2015 and 2020. Also for the purpose of simplicity, only efficient boilers and no other technology for process heating (e.g. Cogeneration systems) have been sized in this study.

Market Potential for Boiler Automation

An improvement in the efficiency of process boilers through automation and optimization has the potential to generate high energy savings and hence would be preferable by Designated Consumers over the replacement of existing boilers. Therefore, the potential for Automation and Control Systems has been estimated for the existing installed capacity of Boilers used for process heating by applying filters of (a) boiler capacity that's likely to get automated and (b) existing level of penetration of Automation and Control systems. Out of the estimated market of around **Rs 100 crores** (based on current boiler capacity across the sectors of focus) which is likely to be penetrated over the next 3-4 years, the lion's share is expected to be consumed by fertilizer sector (39%) followed by textile (27%).

Figure 8: Estimated Investment Potential for Boiler Automation (Rs 100 crores)



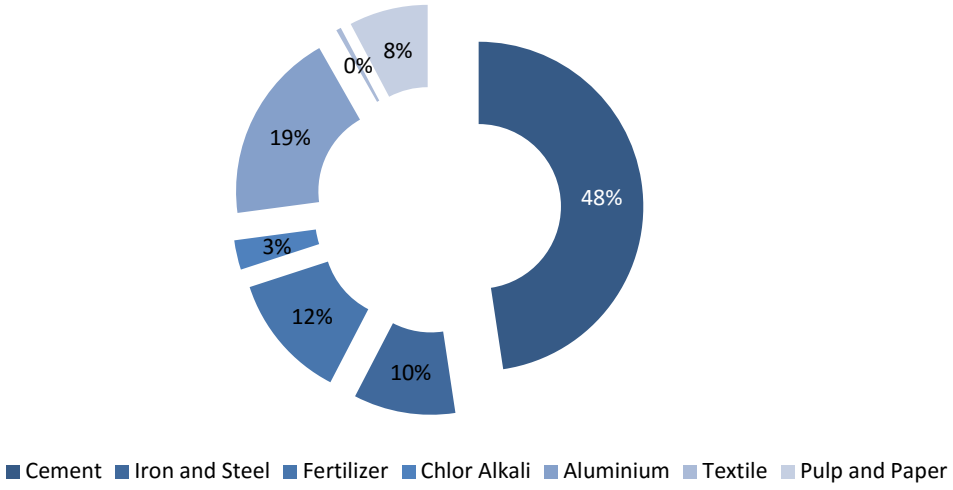
Source: Sustainability Outlook – AEEE analysis

Sector Specific Process Improvements estimated to have maximum investment potential: Rs 17,000 crores

As discussed in our January 2016 issue of PAT Pulse (click to access), process improvements are likely to dominate efficiency interventions in the near term. Such **interventions are typically characterized by relatively high capital expenditure and low current penetration.** Some of the key interventions across the various sectors as identified by sector experts and DCs are illustrated in the table below. These energy efficiency interventions are likely to see significant uptake in the next 3-4 years.

The investment for each of the process interventions assessed has considerable variation – with some being relatively less capex intensive than the others. The total investment per sector is also dependent on the number of DCs to which the process intervention under focus is potentially applicable. Considering the investment potential of the listed interventions, cement sector is estimated to have the maximum scope in terms of quantum of investment followed by fertilizer (as can be seen in Figure 9).

Figure 9: Investment potential of process linked interventions



Source: Sustainability Outlook – AEEE analysis

Sector	Process linked energy efficiency interventions
Cement	• Vertical Roller Mills for Finish Grinding • Use of EAF slag - CemStar • High efficiency clinker coolers • Conversion of Open Circuit Cement Mills to Closed Circuit by Installing High Efficiency Separator • Installation of High Efficiency Dynamic Separator for Raw Mill
Chor Alkali	• Anode and Membrane replacement along with Zero gap conversion of Electrolyser • Ion Exchange Membrane Cell Process -Adaptive Control system • VAM system for utilization of hydrogen produced during electrolysis • Thyrister based rectiformers (electrically controlled, used for high power converter applications) Heat recovery by brine and chlorine recuperator for preheating the feed brine towards the cell
Iron and Steel	• Waste Heat recovery from sinter bed • Coke Dry Quenching • Top Pressure Recovery Turbine • Programmed heating in coke oven • Automated Combustion Control of Coke Ovens • Stamp charging & Partial briquetting of coal charge • Waste heat utilization for charge pre-heating in a sponge iron manufacturing process • Pulverized Coal Injection • Convection Heating type heat treatment Furnace for Wire Rod Coil

Fertilizer	• Installation of Vapour Absorption System • Two Stage Regeneration in CO2 Removal System • Retrofitting Steam Turbines for Higher Efficiency • Using an Adiabatic Pre-reformer • Pressure Swing Adsorption for Purification • Synthesis Gas Molecular Sieve Dryer And Direct Synthesis Converter Feed • Installation of a Second Turbo Alternator in Sulphuric Acid Plant • Installation of Plate heat exchangers for drying tower cooler in sulphuric acid plant
Pulp and Paper	• Installation of Extended Delignification System for Cooking of Wood • Firing of Black Liquor at High Concentration • Installation of Shoe Press in Paper Machines • Installation of High Pressure Cogeneration Systems • Replacing Pneumatic Conveyors with Belt Conveyors
Textile	• High Speed Carding Machine • Replacement of lighter spindle in place of conventional spindle in a Ring Frame • Installation of FRP blades in place of Aluminium alloy fans in humidification • Use of steam coil instead of direct steam heating in Jiggers • Conversion of thermic fluid heating system to Direct Gas Firing system in Stenters and Dryers • Installation of electronic Roving end break stop- motion detector instead of pneumatic system • Plasma technology for hydrophobic finishing
Aluminum	• Seal Pot System for Condensate Recovery • Inert anode (PBANOD) in Hall Heroult Process • Slotted Anode to allow the flue gas to escape • Wetted Drained Cathode technology (Advanced Hall heroult cells) • Replacement of Rotary Kilns with circulating fluidized bed kilns - Fluidised bed calcination Recuperative or regenerative burners in Anode Baking

Note: This list currently does not take into account interventionswhich are still under demonstration stage or haven't seen significant adoption across the globe

Key Challenges for increasing penetration of EE interventions in the industry

- **Lack of clarity in ESCerts trading** is leading to uncertainty amongst DCs who are **unable to clearly assess the monetary impact of PAT scheme**. Currently many DCs are sceptical about factoring in potential ESCerts generated in their return on investment calculations.

"ESCerts trading is likely to be the acid test for PAT scheme as a market development platform"

- **Large saving potential interventions require high capex:** Some of the key sector specific process improvements which will move the needle on energy savings also have a high upfront capex. These include:
    - Anode and Membrane replacement along with Zero gap conversion of Electrolyser in the chlor alkali sector would entail a capital investment of approximately Rs 25 crores for a 250 TPD plant.
    - High efficiency clinker coolers require an investment of Rs 100 – 150 / tonne of clinker
    - Inert anode (PBANOD) in Hall Heroult Process in Aluminium sector entails capex of Rs.5590 /tonne

- **Practical constraints other than capex, such as lack of space, production shut down, lack of suppliers, changing fuel prices etc. also limiting the adoption of EE** interventions linked to process improvement.
    - Non-availability of space is a key constraint for carrying out heat exchanger modifications, especially in the fertilizer sector.
    - Waste Heat Recovery, though has a high potential of energy savings, has seen relatively low penetration in the steel sector due limited number of local suppliers. Globally, WHR market for the steel sector is dominated by a few suppliers – none of which have local Indian presence. Moreover, since some applications of WHR require plant shut down for a relatively long duration (time required is 3 times in steel plant compared to cement plant), the loss of production renders the WHR application unattractive in comparison.
    - For sectors such as fertilizer, there is a high difference between the vintage of plants ranging from 1960 to 1990s. The industry has already achieved significant reduction in the specific energy consumption and process modification is the only way forward especially for the old plants (as even they have been successful in reducing their energy consumption by 15-16% in the last 10 years). In case of a few old units, revamp of the entire equipment setup would be required, which would be mammoth task. Moreover, any such modifications have to be vetted by the process licensors as per the protocol.
- **Lack of robust ESCO models of financing to make investments more attractive**
    - Balance sheet based finance for the DCs is unlikely to help the energy efficiency leap frog into the next level. Cash flow/savings based financing is needed to spur the ESCO market in the country. Industry is also looking for performance based contracting.
    - With the crude oil price and gas market depressed, the payback period for the process modifications is going up for certain sectors which are primarily dependent on these as fuel.

Way forward

As is evident, industrial energy efficiency presents a significant investment opportunity both in the near term and long term. In order to capitalize on this and build the EE market in India on a sustainable basis, the following areas need to be focused on:

Enhanced technical competencies of service providers and DCs

In order to help DCs accelerate action on energy efficiency, it is important to enhance the supporting ecosystem of service providers including ESCOs, energy efficiency auditors, energy consultants as well as increase capacity of existing staff (at all levels) within the DC.

- **Capacity building of service providers:** Many DCs are of the opinion that currently there seems to be a gap between the existing competencies of service providers such as auditors, consultants and ESCOs and what's required in order to take the next big jump in energy efficiency improvements in industrial sectors
    - Technical Comprehensive assessments need to be undertaken to understand potential energy conservation and efficiency improvement opportunities, eg: process integration through pinch technologies has not been carried out by Energy Auditors or BEE so far. Such studies would require an elaborate technical arrangement and a time of at least 12-30 weeks
    - Monitoring and verification using standardized measurement protocol
    -

Suggested measures for capacity building of supporting ecosystem of energy efficiency

- **Creating collaborative platforms to enable dialog, insight and actio**n on innovative and upcoming energy efficiency interventions amongst multiple stakeholders (DCs, ESCOs, technology suppliers, energy auditors)
- Conducting regular trainings (say on quarterly basis) for energy auditors/ESCOs which focus on utilities (cross-cutting) as well as sector specific processes (potentially making certain hours of training mandatory per year)
- Periodic evaluation of service providers - Empaneled Energy auditors/ESCOs in order to maintain their accreditation

- **Training within DCs:** Regular trainings are needed across all levels in DCs, including top management, persons associated with Significant Energy Use (SEU) processes/equipment, workmen etc. Also, capacity building activities should be designed to suit the needs of the particular sector.
    - Adequate implementation support including training and capacity building regarding operations and maintenance needs to be provided while installing new energy efficiency equipment, making process improvements etc. such that the true impact of the particular is realized in a sustained manner
    - Also, training for regular monitoring and performance assessment of existing energy consuming equipment such as motors, compressors, pumps, HVAC etc is needed.

Training areas for DCs (with cross-sectoral applicability)

- To create awareness & make more emphasis on optimum use of Energy and to reduce wastage of Energy and provide tips on energy conservation in various equipment
- To provide basic knowledge in selection Energy Efficient Equipment
- To provide basic knowledge in optimization of Energy Use of Energy Efficient Equipment (motors, compressors, cooling towers, lighting and air conditioning equipment, steam traps, etc)
- To evaluate the efficiency of pumps, compressor and heat exchangers

Source: Inputs from DCW Ltd, Sahupuram

Need for market making mechanism

With energy efficiency interventions that have cross sectoral applicability (thereby a sizable demand), are easy to implement and have high impact on energy efficiency performance, there can be collaborative purchases to reduce cost and accelerate their adoption. One such case could be that of Variable Frequency Drives (VFD) which can follow the model of **leveraging cross sectoral aggregate demand to achieve price reduction** with a nodal agency acting as the facilitator. A successful example is the price reduction achieved on LEDs for domestic consumers due to demand aggregation and bulk purchase by the government through its implementing agencies under the UJALA scheme.

Robust ESCO financing models

Going forward, many energy efficiency interventions are likely to require significant upfront capital investment which may necessitate the need to have innovative financing mechanisms such as robust ESCO models which can reduce the burden of direct capital investment by DCs.

The upcoming briefs of PAT Pulse will delve deeper into some of these areas. The next issue of PAT Pulse will focus on demystifying the current financing landscape and the potential financing models of intervention/options which can enable the sector to tap into the potential investment opportunity.

Endnotes

Sources for charts on Average Specific Energy Consumption – India vs Global

- Fertilizer: India -Presentation on PAT scheme by BEE (2012); World - FAI
- Cement: India and World (2015) - https://www.icef-forum.org/annual_2015/speakers/october7/cs1/c/pdf/cs-1_20023_surrinder_kumar_handoo.pdf
- Iron and Steel: India -Presentation on PAT scheme by BEE (2012); World - World Best Practice Energy Intensity Values for Selected Industrial Sectors- LBNL (2008)
- Aluminium: India -Presentation on PAT scheme by BEE (2012); World – http://www.aluminum.org/sites/default/files/Aluminum_The_Element_of_Sustainability.pdf (2007)
- Textile: India -Presentation on PAT scheme by BEE (2012); World – http://www.unido.org/fileadmin/user_media/Services/Energy_and_Climate_Change/Energy_Efficiency/Benchmarking_%20Energy_%20Policy_Tool.pdf (2008)
- Chlor Alkali: India -Presentation on PAT scheme by BEE (2012); World – LBNL: Assessment of Energy use and energy savings potential in Industrial sector India (2005)
- Paper and Pulp: Central Pulp and Paper Research Institute

PAT Pulse
[MAY 2016]

Alliance for an Energy Efficient Economy

Sustainability Outlook

POLICY UPDATE

Draft Central Electricity Regulatory Commission (Terms and Conditions for Exchange of Energy Savings Certificates) Regulations, 2016.

CERC notified the **Draft Central Electricity Regulatory Commission (Terms and Conditions for Exchange of Energy Savings Certificates) Regulations, 2016** on 3rd February 2016 on account of the power conferred on it as per the Electricity Act, 2003, National Electricity Policy and Energy Conservation (Energy Consumption Norms and Standards for Designated Consumers, Form, Time within which, and Manner of Preparation and Implementation of Scheme, Procedure for Issue of Energy Savings Certificate and Value of Per Metric Ton of Oil Equivalent of Energy Consumed) Rules, 2012.

The public notice thus released, invited comments / suggestions / objections on the draft regulations by 22nd February 2016. CERC also organized a public hearing for all the stakeholders on 4th March, 2016 at CERC Court Room, 4th Floor, Chandralok Building, 36, Janpath, New Delhi- 110001 to arrive at a fair conclusion in regard to the draft regulations.

The objective of the regulation is to outline a framework for exchange of Energy Savings Certificate on Power Exchanges in accordance with the Power Market Regulations. The ESCerts issued to the designated consumer in electronic form for consuming energy units less than that specified by the Central Government, can be transacted on any of the Power Exchanges as per the regulation.

The draft regulations also proposed responsibilities for Bureau of Energy Efficiency (BEE), Central Electricity Regulatory Commission (CERC) and Power System Operation Corporation Limited (POSOCO).

BEE was deputized as the administrator of ESCerts under the notification. BEE was held responsible for the following activities:

- Defining procedures with approval from CERC, for interface activities between Power Exchanges and Registry, Administrator and Registry, and Registry and Designated Consumers
- Assisting CERC on matters related to exchange of ESCerts on Power Exchanges.
- Disseminating the relevant information to the stakeholders.
- Issuing detailed procedure for registration of eligible entities, transfer, exchange, banking, extinguishment of ESCerts and other residual matters.
- Coordinating with Power Exchanges and registry for smooth exchange of ESCerts.
- Ensuring transparent exchange of ESCerts
- Discharging such other functions as mentioned in the regulations.

CERC was assigned the responsibility of a market regulator. The functions vested on CERC as per the draft notification included:

- Approval of procedures for interface activities between Power Exchanges and Registry, Administrator and Registry, and Registry and Designated Consumers in enactment of the Energy Conservation Rules.
- Monitoring of performance and operations of Power Exchanges in relation to exchange of ESCerts.
- Directing BEE in relation to discharge of its functions in regard to exchange of ESCerts.

The function of Registry of ESCerts trading was assigned to POSOCO by Ministry of Power, under the draft notification. POSOCO as the registry was expected to discharge the following functions:

- Providing assistance to the designated consumers for registration of ESCerts with approval from Ministry of Power. In order to meet the expenses and cost for management of the registry and software platform, POSOCO may collect fees from the eligible units, as approved by CERC in consultation with BEE.
- Guiding the process of exchange and transfer of ESCerts by tracking transactions and ownership of ESCerts, developing methodology for settlement of ESCerts trade, keeping records of banking of ESCerts, etc.

- Cording and disseminating information with Powwer Exchanges, Designated Consumers, BEE and CERC.
- Assisting in development of IT platform along with providing guidance on hardware infrastructure for maintaining records of of ESCerts trading and database of ESCerts.
- Making draft procedure for approval of the commission
- Discharging any other function assigned by CERC in consultation with BEE, after real market condition assessment and execution of the trading mechanism.

Source: http://www.cercind.gov.in/2016/draft_reg/PN.pdf, http://www.cercind.gov.in/2016/draft_reg/Noti.pdf, http://www.cercind.gov.in/2016/draft_reg/EM.pdf

INNOVATION LENS

Some of the latest innovations and development of new technology in the area of energy efficiency that have been successfully demonstrated their potential are listed here

KM CDR Process- Mitsubishi Heavy Industries Ltd.

Applicable sector:

It is applicable for both small and large scale industries. It can recover CO_2 from wide varieties of flue gas source, such as gas firing, oil firing and coal firing.

Likely impact:

- Capable of recovering CO_2 emissions up to 90%
- Reduce energy consumption
- Reduce solvent degradation and corrosion

Source: MHI-Global

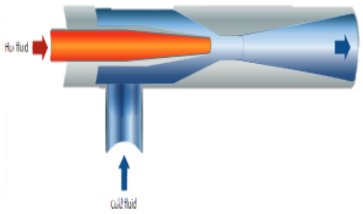
Description: The Kansai Mitsubishi Carbon Dioxide Recovery Process (KM CDR Process) utilizes KS-1 solvent, which is an advanced hindered amine solvent in association with special equipments for recovering CO_2 from flue gas. The flue gas is directed to a vessel during the process for the solvent to selectively capture the CO_2. The solvent rich in CO_2 is then directed to another vessel for heat exchange and then pumped into the stripper thus yielding CO_2 of high purity (99.9 vol. percent or more). CO_2 thus released is compressed and stored below the ground, while the solvent is recovered and re-circulated.

Source: https://www.mhi-global.com/

CanmetENERGY's Innovative Ejector Technology

Applicable sector:

The technology can be used in various industrial for heating, heat upgrading, in cooling towers, refrigeration, etc.



Likely impact:

- Improvement in energy efficiency by 20%
- Decrease in energy compressor requirement by 10%
- Reduction of 15-30% in the operating costs related to CO_2 removal

Source: CanmetENERGY

Description: Ejectors are technology alternative for mechanical compressors using thermal energy for creating vaccum. It can be used for mechanical compression, absorption and adsorption systems. CanmetENERGY's innovative ejector technology is much smaller and can utilize wide varieties of operating refrigerants in comparison to traditional ejector. This innovative technology has the capability of increasing overall productivity and reducing energy intensity of industrial processes.

Source: http://www.nrcan.gc.ca/

Very High Frequency Switch Mode Power Supplies (VHF SMPS), Nordic Power Converters

Applicable sector:

This innovative technology can be utilized for any application, requiring power converters, like LED lighting. It is appropriate for both DC/DC and AC/DC power converters and for high and low power levels.

Likely impact:

- Increases in lifetime by removal of less reliable electrical components
- Decrease in size and weight by 80%
- Greener footprint due to removal of rare earth metals and use of less material

Source: Nordic Power Converters

Description: The technology by Nordic Power Converters is not only much more efficient than the conventional power converters, but also is much lighter and has a longer lifetime. This technology requires new methods of designing the power converters and has been developed by combining design methodology of power electronics with the RF industry. Due to its unique design, switching losses are eliminated and the need for many unreliable electrical components like electrolytic capacitors is wiped out.

Source: http://nordicpowerconverters.com/

Eco-applicator Soft Coating Solution, Monforts

Applicable sector:

- It can be used for felt finishes, coated materials and medical textiles
- Application of coating material and chemicals on one side of the fabric
- Application of coating material and chemicals on both sides of the fabric
- Application of liquid coating material on one side and a different coating material on the other side

Likely impact:

- Provide significant energy savings
- Reduce drying time
- Reduce the amount of coating material applied
- Eliminate the need for conventional wet-on-wet padder.

Source: Monforts

Description: The Eco-Applicator soft coating process from Monforts for the application of liquors and functional chemicals, now available for even denim fabric application is an innovative technology with huge energy saving potential.

The multi-functional and multi-purpose Eco-Applicator process uses roller for application of the coating material on the fabric (twin-roller for dual-sided application) and hence eliminates the requirement of the conventional, less efficient wet-on-wet padder technology.

The use of this technology involves minimal liquor application and hence reduces initial moisture content to 40% in comparison to 60% in padder system, thus reducing the drying time and bringing about substantial energy savings

Source: http://monforts.com/

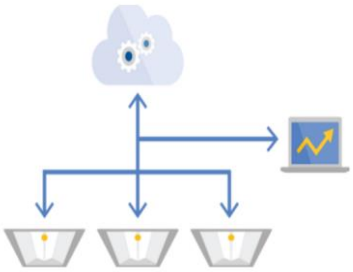
IoT Lighting from Cree, Cisco Automatically Saves Energy by Connecting Ceilings to the Cloud

Applicable sector:

The SmartCast Technlogy can be customized for each building to increase overall energy efficiency.

Likely impact:

- It is likely to deliver up to 70% more savings than standard LED lighting.
- It can assist in providing better light and hence creating more productive buildings.

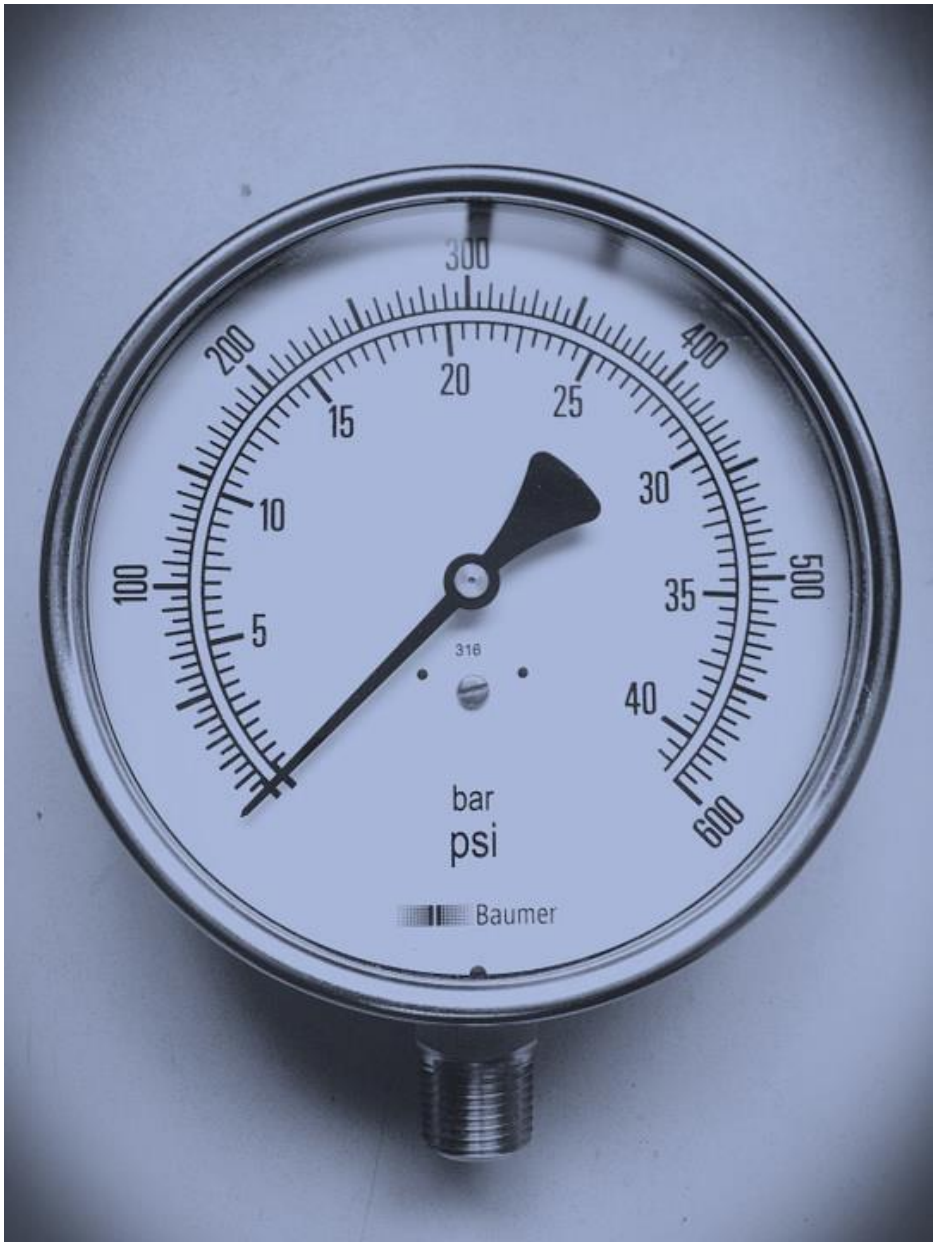


Source: Cree

Description: The SmartCast Technology is much more improved than the standard LED lights. The technology connects lighting to a secure and smart building system with business analytics, which helps in reducing the total costs. The light switches, dimmers and Cree's SmartCast lights operate on the network architecture developed by Cisco to provide power and networking for the lights with a standard Ethernet cable, hence eliminating the requirement of separate data and high-voltage power connections.

The initial installations of the technology, is in progress and the commercial availability of the technology is expected to be available in the second quarter of 2016.

Source: http://cree.com/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NEWS WIRE

Key News Highlights

India to Save up to $6 Billion from LED Lighting Upgrade

January 12, 2016:

The climate group reported that with the government commitment to completely switch India lighting sector with LEDs by 2018, India would save up to $6 billion yearly. "When all the 71 crore conventional bulbs are replaced by LED bulbs it will result in a saving of 100 billion units of electricity," said the Minister. The climate group has proven through its projects the energy and money saving potential of energy efficient lighting such as LEDs.

As compared to global average of 13%, the Indian lighting sector average is about 18% of the country's power production. This gives a clear indication of huge savings potential from this sector alone (between 50-70%). Besides the direct benefits of adoption of LEDs like significant cut in carbon emissions, there are also various co-benefits such as further reduction in global average, and at the same reduction in additional electricity demand.

Source: http://www.theclimategroup.org/what-we-do/news-and-blogs/india-to-save-up-to-6-billion-from-led-lighting-upgrade/

India Seeks Joint Collaboration with Japan on Energy Efficiency, Conservation

January 14, 2016:

The 8th India-Japan Energy Dialogue strengthened the partnership between the two countries, sketching out clear roadmap to facilitate collaboration in the fields of renewable energy, electricity, coal & petroleum & natural gas and energy efficiency and conservation.

Piyush Goyal, union minister of state for power, coal and new & renewable energy highlighted the need for usage of energy efficient measures and promotion of renewable energy as a way forward for the Indian power sector. He also emphasized the need for Japanese and Indian industries to innovate, such technologies which shall assist in meeting energy needs of India. He stressed on energy efficient measures in various sectors like agriculture and also called upon industries to implement energy efficiency projects in a comprehensive package so as to provide facilities starting from energy audit to implementation to the consumer.

Source: http://www.business-standard.com/article/economy-policy/india-seeks-joint-collaboration-with-japan-on-energy-efficiency-conservation-116011400337_1.html

Green Bond Market Boost with the Expected Issuance of $50 Billion in 2016: Moody's

February 2, 2016:

According to Moody's Investors Services, as compared to last year's $42.4 billion, companies globally are likely to raise over $50 billion through the issuance of green bonds in 2016.

"In this favourable environment, even after more recent bond market headwinds, and assuming a resumption of the growth rates seen in 2012-14, issuance could exceed $50 billion by a significant margin," Moody's VP Henry Shilling said.

"The regulatory encouragement to issue and invest in green bonds along with the presence of newly issued guidelines for such bonds in China and India will bolster issuance as well," Moody's said in a statement.
The proceeds from these green bonds are earmarked for a variety of projects, including renewable energy and energy

efficiency, financing hybrid and electric automobiles, public wastewater treatment and drinking water projects.

"We expect the momentum from the UN Conference on Climate Change (COP21) as well as the signing of the Paris Agreement scheduled this April to likely motivate additional and repeat issuance of green bonds," Shilling said.

Source: http://www.thehindubusinessline.com/economy/green-bond-issuance-to-top-50-bn-in-2016-moodys/article8182528.ece

Industries in Karnataka Told to go in for Rooftop Solar Power Generation

February 28, 2016:

Industries in Karnataka have been persuaded to harness solar power and become self-supporting in terms of their energy needs. The unutilized terrace space of the industrial buildings can be utilized for the installation of Solar Photovoltaic units for generation of solar power.

In order to spread the communication and encourage the use of rooftop solar power, an awareness programme on rooftop solar power generation was organized at the KIADB Complex, K.R.S. Road, Bengaluru.

Mr. Suresh Kumar Jain, general secretary, Mysore Industries Association stated "Solar power can be generated from rooftop systems at a nominal rate of Rs.6.50/kWh. This works out much cheaper than the power generated through diesel generator sets."

He further added that participation of the industries is necessary to meet the target set by Union Government of India to install 4,200 MW of grid-interactive rooftop solar PV plants up to 2019-2020 under the National Solar Mission (NSM).

Source: http://www.thehindu.com/todays-paper/tp-national/tp-karnataka/industries-told-to-go-in-for-rooftop-solar-power-generation/article8291722.ece

Indian Aluminium Company to Invest $100 Million in Renewable Energy

March 14, 2016:

The government owned, National Aluminum Company Limited (NALCO) announced plans to make a mammoth investment of $100 Milion (Rs. 700 crore) in renewable energy sector.

NALCO already has operational renewable energy assets like 98 MW of wind energy projects in Andhra Pradesh and Rajasthan and intends to further set up two more large scale wind energy projects. The company also intends to develop large scale solar power projects to increase renewable energy share in its electricity consumption.

Source: http://cleantechnica.com/2016/03/14/indian-aluminium-company-invest-100-million-renewable-energy/

State-run Energy Efficiency Services Inks Pact with IIFC Projects

March 17, 2016:

The state run Energy Efficiency Services (EESL) signed an agreement with IIFC Projects, under which IIFC Projects shall undertake the responsibility of expanding the business portfolio of EESL as its financial and technical advisor. The partnership, IIFC Projects Ltd (IPL) shall also assist EESL to create a market for its new product and developing strategies for its already existing as well as new product lines thus accelerating its business potential.

IPL intends to provide services and solution for al kinds of infrastructure projects.

"This Memorandum of Understanding (MoU) marks an important step towards our commitment to energy efficiency and tapping potential in every possible sector in the country," EESL MD Saurabh Kumar said.

Source: http://www.dnaindia.com/money/report-state-run-energy-efficiency-services-inks-pact-with-iifc-projects-2190459

DATEBOOK

Managing Cost of Energy: Improving Efficiency, Optimizing Sourcing

Date 9 May 2016 – 10 May 2016
Location The Grand, Vasant Kunj, New Delhi
Type of event Conference
Organiser PowerLine, Indian Infrastructure, RenewableWatch
Key themes
- The Status of roll-out of PAT Cycle II
- Key learnings from PAT Cycle I and how it can be incorporated in Cycle II
- Commencement of ESCerts issuance and the potential mechanism for exchange and trading of ESCerts
- Fuel cost management options and strategies available for the industries

Link http://www.indiainfrastructure.com/conference/conference-managing-cost-of-energy-april2016.html

2nd Smart Cities India 2016 Expo

Date 11 May 2016 - 13 May 2016
Location Pragati Maidan, New Delhi, India
Type of event Conference and Exhibition
Organiser Exhibitions India Group
Key themes
- Smart Environment
- Smart IT & Communications
- Clean Energy
- Smart Buildings
- Smart Water and Waste Management
- Smart Grid
- Smart Urban Planning
- Smart Security and Safety

Link http://www.smartcitiesindia.com/

CMVP Training and Examination

Date 26 May 2016 – 28 May 2016
Location Chennai
Type of event Training
Organiser AEEE and EVO (USA)
Key themes The objective of the training is to raise the professional standards of the people who are involved in measurement and verification, and to recognize the most qualified professionals in the emergent energy industry.
Link http://www.aeee.in/event/11th-cmvp-training-and-examination/

Energy Efficiency in Emerging Economies

Date	6 June 2016 – 10 June 2016
Location	IEA headquarters, Paris
Type of event	Training
Organiser	**IEA**
Key themes	Cross-sectoral sessions on assessment of the potential for energy efficiency and the socio-economic benefits of energy efficiency measures.
Link	https://www.iea.org/training/energyefficiencytrainingweek2016/

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About Shakti Sustainable Energy Foundation

Shakti Sustainable Energy Foundation works to strengthen the energy security of India by aiding the design and implementation of policies that support energy efficiency and renewable energy

About Sustainability Outlook

Sustainability Outlook, a division of cKinetics is a market access, insight and collaboration platform tracking actions related towards enhanced resource management in the Indian economy. Sustainability Outlook provides market analysis and data tracking services, news and intelligence updates, and creates momentum towards specialised sustainability interventions by facilitating a structured process for multi-party collaboration.

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About AEEE

AEEE is an industry association created for the specific purpose of convening companies and organizations (manufacturing companies, end users, service providers, utilities, academic and R&D institutes and other non-profit organisations) interested in creating a thriving energy efficiency sector in India and providing a unique platform to actively participate and support in energy efficiency policy formulation and analysis.

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