Alliance for an Energy Efficient Economy

Sustainability Outlook

SHAKTI SUSTAINABLE ENERGY FOUNDATION

PAT Pulse

Tracking the Perform-Achieve-Trade Scheme for Energy Efficiency

COMPENDIUM 2016

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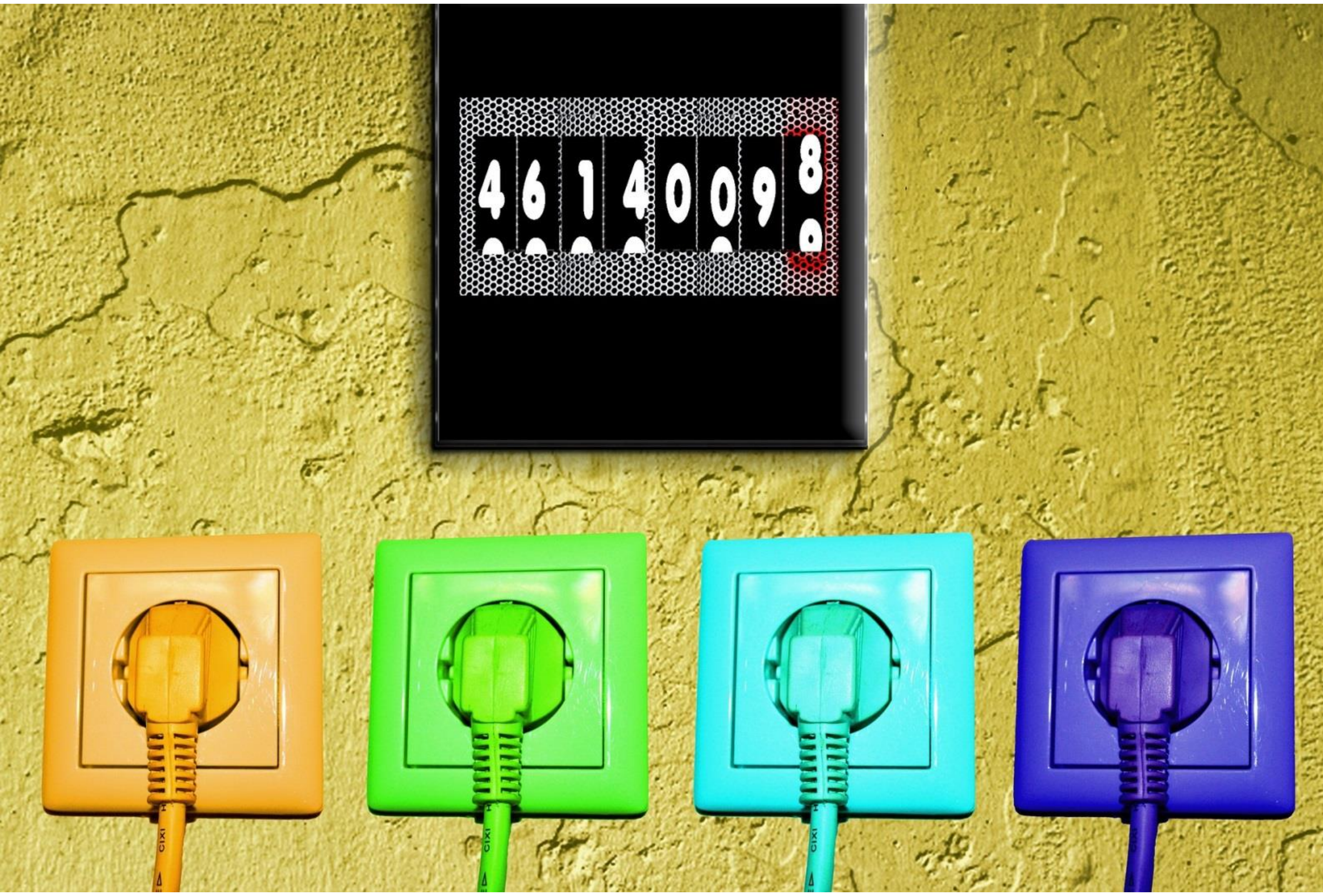
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Executive summary

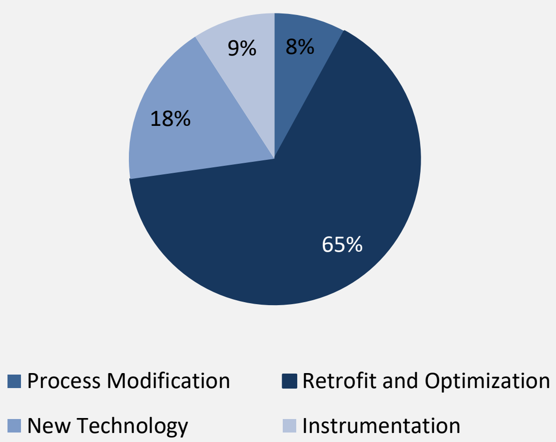
Given the accelerated growth of the industrial sector and the huge growth in infrastructure envisaged, there is need to shift the focus towards achieving high efficiency in industrial systems and processes. Focusing on energy efficiency is also in line with India's commitment to fight climate change. The Perform-Achieve-Trade (PAT) scheme was formulated to achieve this objective by facilitating a market based mechanism for promoting energy efficiency.

Sustainability Outlook and Alliance for Energy Efficient Economy (AEEE) in collaboration with Shakti Sustainable Energy Foundation initiated 'PAT Pulse', 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. Having published four editions of PAT Pulse during the course of 2016, this compendium is a compilation of the key research and analysis of all the issues released in 2016 which focused on multiple domains including sizing the investment potential and financing framework for industrial energy efficiency to innovations in smart manufacturing.

Cross-Sectoral Learning & Process Innovation will drive the second phase of PAT

In the first issue of PAT Pulse published in January 2016, Sustainability Outlook and AEEE conducted a survey with a sample of 47 Designated Consumers (DCs) from the 8 PAT sectors and reviewed 426 projects undertaken in Phase 1 of the PAT scheme. The survey revealed that DCs in the first phase were focused on addressing efficiency mainly through retrofits and routine optimization.

Types of Energy Efficiency Projects undertaken in PAT phase-I



Source: Survey result, Sustainability Outlook-AEEE Analysis

The key take-aways from the survey were:

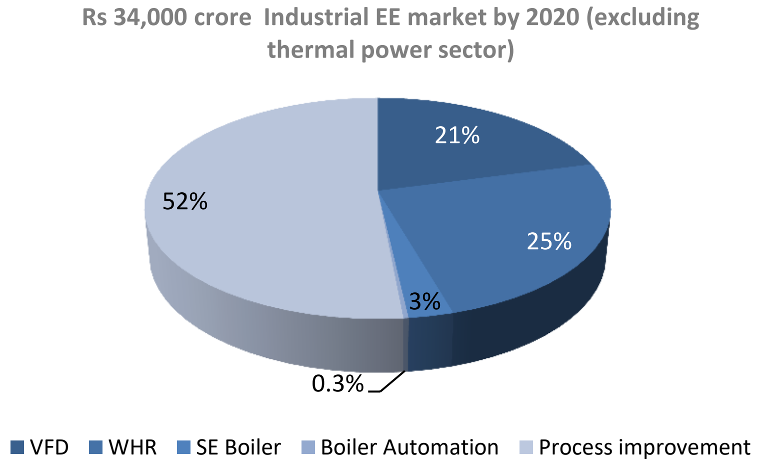
- The first phase was largely characterized by low capex and short pay-back projects. Almost 65% of the projects fell in the low cost-retrofit projects' category.
- The focus was primarily on driving utility and component efficiency rather than process and/or systems efficiency.
- More than 60% of projects carried out were relevant across sectors
- Almost 70% of the retrofit and optimization projects were cross cutting in nature, including installation of VFDs etc.
- Regarding the up-take of ESCO model, a significant majority of the DCs surveyed indicated that they had implemented the projects themselves rather than outsourcing the same to ESCOs which is an over-arching trend across all the sectors.
- The DCs also expressed a need for enhanced action on financing models and ESCerts trading.

Overall, the first issue, through the interview with the DCs helped us gain significant results; key ones being:

- Process innovation, availability of low cost finance and ESCerts trading hold the key to success of second cycle of PAT;
- The outlook for the second phase is tilting towards process innovation and overall system efficiency;
- There exists a significant potential to exploit cross-sectoral techniques of energy efficiency

Rs.34,000 Crore Energy Efficiency Investment Opportunity Awaits Indian Industry

The second PAT Pulse brief rooted itself with the fact 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 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 for the same. The potential of industrial energy efficiency interventions for the DCs across the PAT sectors (excluding thermal power sector) was estimated to be Rs 34,000 crores (~USD5 billion) -- 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.

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.

Some of the other key findings from this issue were:

- Potential market of Rs 7,000 crore for Variable Frequency Drives across sectors with sizable potential in Iron and Steel, Cement, Aluminum and Fertilizer
- Cement and Iron and Steel likely to lead the Rs 8,000 crore waste heat recovery Market across the 7 PAT sectors (excluding thermal power sector)
- Textile and Paper and Pulp sectors have significant market potential for super-efficient boilers for process heating. Focusing on these two sectors only, the overall market for super-efficient boilers has been estimated to be Rs 900 crores by 2020 with textile sector accounting for 67% of the total estimate.

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.

Financing Energy Efficiency in India - Who Will Invest?

The September 2016 issue of PAT Pulse attempted to go a step further from the estimated investment opportunity for industrial energy efficiency market, and explore its dynamics in greater depth. The key objectives of the outlook brief were to analyze the most optimal financing routes to realize the investment potential presented in the energy efficiency domain in PAT sectors (excluding thermal power sector) and to assess the strengthening measures needed for achieving a successful and sustainable trajectory for industrial energy efficiency market in India.

The key highlights of this issue included:

- Financing patterns are determined by two factors:
    - Size of the Designated Consumer (and/or its parent). Those with fixed assets of Rs. 500 crore and above were classified as “large”; and others are small.
    - Whether companies will put in their share of contribution as part of the overall financing; or expect 3rd parties to do so.
- Cross-cutting Technologies (e.g. VFDs, Waste Heat recovery, etc. that cut across industries) have maximum potential for Vendor finance/ESCO model
- Projects in Chlor-Alkali and Aluminium sector can account for maximum financing through project specific term loans whereas Cement and Fertilizer can get clubbed with loans within existing lines of credit
- Policy push and standardization in EE projects are key levers to realize the investment potential

Sustainability Outlook and AEEE developed a decision matrix which will help assess the most optimal route for financing energy efficiency interventions. This matrix considers the following variables:

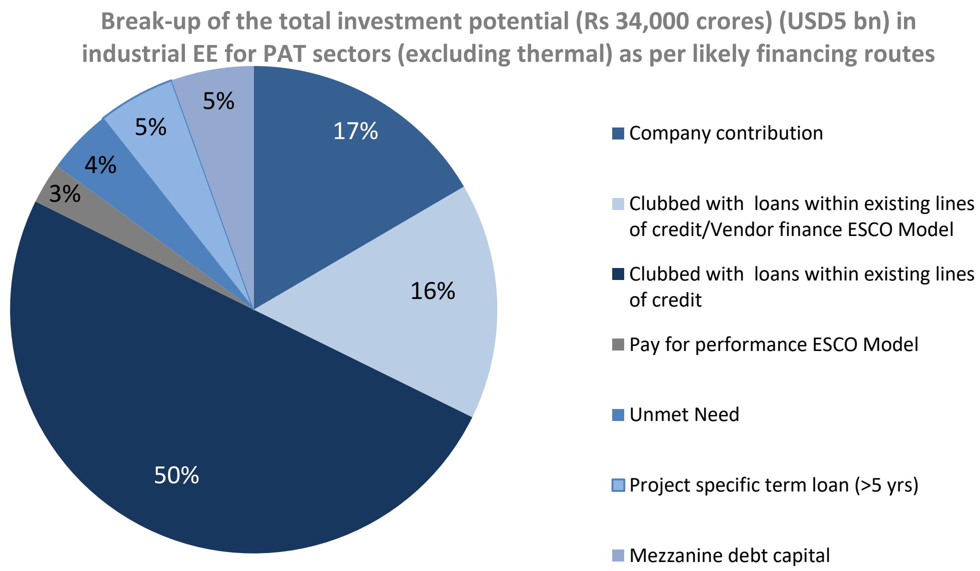
1. Type of Energy Efficiency intervention
    a. What is the significance of capital expenditure required for the intervention (as a percentage of total capex required by the firm to set up manufacturing capacity in that sector)? (any intervention which requires more than 3% of the firm’s capex was considered as significant)
    b. What is the simple payback of intervention? (less than 3 years was classified as short term, between 3 and 5 years as medium term and greater than 5 years as long term payback)
    c. Whether the intervention is a cross cutting technology or linked to process improvement?
2. Type of firm undertaking the intervention
    d. Size of fixed assets (as a measure to gauge the size of the firm)
    e. Strength of the balance sheet

Keeping the above metrics in mind, the optimal financing routes for the energy efficiency interventions considered for the purpose of this analysis were primarily the following:

1. Project Specific Term Loan (>5 yr tenure)
2. Clubbed with loans within existing lines of credit
3. Vendor finance ESCO model
4. Pay for Performance ESCO model
5. Mezzanine Debt Capital

The analysis also found that suitable financing routes do not exist for certain EE interventions and thus their financing needs remain unmet.

Thus, the key conclusions from the model developed in this brief were that out of the total investment opportunity in industrial energy efficiency across the 7 PAT Phase 1 sectors (excluding thermal power sector), estimated as Rs. 34,000 crore approximately by 2020 -- 17% or approximately Rs 5,500 crores (USD 0.8 billion) would be required as company contribution /equity/margin money. The remaining 83%, i.e. Rs 27,000 crores (USD 4.2bn) can have multiple financing routes including: Project Specific Term Loan (>5 year tenure); Clubbed with loans within existing lines of credit; Vendor finance ESCO model; Pay for Performance ESCO model; Mezzanine Debt Capital.



However, currently the key challenge is unwillingness of many companies to invest equity in savings projects such as those linked to energy efficiency instead of growth projects which in turn will enhance their top line performance. Risk Guarantees (performance risk and credit risk) can play a significant role in helping the industrial energy efficiency realize its potential. Further, a policy push to prioritize energy efficiency – through more stringent energy efficiency norms, a policy that levels playing field for all companies in a sector and tax incentives for industry (companies) to adopt ESCO route could be some steps to encourage the industry to adopt energy efficiency measures.

The brief emphasized on how a 'market-maker' is missing in the industrial energy efficiency space -- bringing industry, financial institutions and ESCOs together. Collaboration is very important to take a combined responsibility for the bigger issue—i.e. enhancing the energy efficiency among industries in an ethical, responsible and definitely in a sustainable way.

Asset Optimization to Drive the Next Wave of Energy Efficiency in India

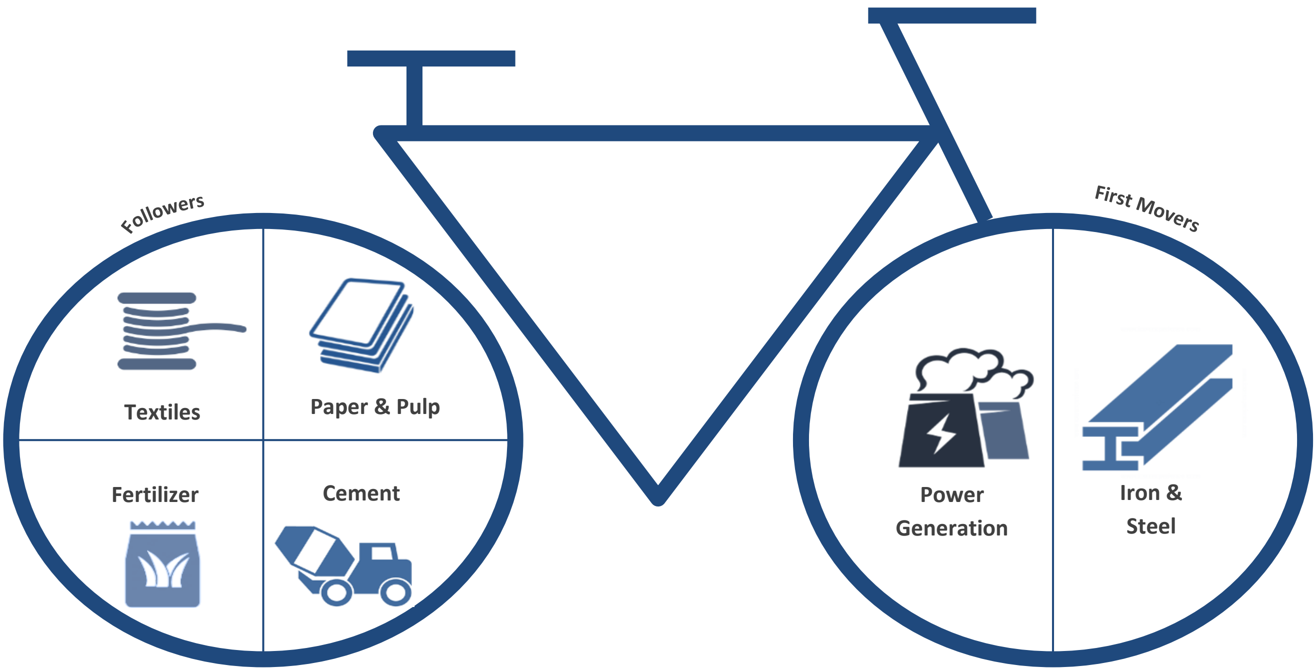
The next issue of PAT Pulse focused on one of the most trending and significant aspects in the industrial energy efficiency space – Internet of Things (IoT) based smart manufacturing (SM) solutions (for applications within the factory's fence). Achieving performance efficiency and cost savings through optimization of Overall Equipment Effectiveness is likely to define the next wave of Industrial Energy Efficiency. Thus, the prevalence, drivers, business case and key challenges for IoT based Smart Manufacturing solutions in Indian industry were explored in this issue of PAT Pulse.

Some of the highlights of this issue included:

- Achieving performance efficiency and cost savings through optimization of Overall Equipment Effectiveness will define the next wave of Industrial Energy Efficiency.
- The market penetration of IoT based smart manufacturing solutions will increase from current levels of ~5% to 30% by 2020 and this would be driven by reduction in the cost of technologies.
- Increasing awareness about the potential and business case of IoT based smart manufacturing solutions will be crucial to reach the next stage of Industrial energy efficiency.
- Skill building would be required for enhancing the ease of using IoT based smart manufacturing solutions at the factory operators' end and for developing good quality data scientists at the solution providers' end.

Within PAT sectors, so far, iron and steel and power generation have seen the highest interest in IoT based smart manufacturing solutions. In both these sectors, the optimized operation of equipment based on their design specification and monitoring of various sections within the plant are the areas where IoT based SM solutions find applications. In the iron & steel sector, the heavy machinery involved in movement of material (such as cranes, etc.) provides an opportunity for IoT based solutions. Other PAT sectors such as textiles, paper & pulp, fertilizers and cement have also shown some interest and depending on their size have initiated pilots for implementation of IoT based SM solutions. Among non-PAT sectors, the automotive sector which has usually been at the helm of digitization has seen good uptake of IoT based solutions. Retail, transportation, oil & gas, pharmaceuticals, utilities, health care, consumer goods, smart cities, renewable energy generation and consumer electronics have also seen increasing interest.

PAT Sectors that are using IoT Based SM Solutions



It is important to note that certain specific utilities that exist across sectors such as boilers and steam distribution systems, compressed air systems and water and waste water treatment may see quicker uptake of IoT based SM solutions and present many case studies for other interested factories to use. India's good cellular infrastructure is already paving the way for ensuring reliability of data transfer.

The way forward for IoT based SM solutions would necessarily need to commence with improvement of awareness about available solutions. This could be addressed by solution providers by making more case studies and project references available to manufacturers which could help them gain confidence. Further, if the solutions are implemented in units that belong to an industrial cluster, it would help in spreading the experience through word of mouth among various factories within the cluster. Also, to make factories more ready for such solutions, the skill sets of the operational staff needs to be enhanced through classroom and shop floor trainings using aid such as manuals, videos, hands on sessions that give out step by step procedures in a simplistic manner.


CREE

CROSS-SECTORAL LEARNINGS & PROCESS INNOVATIONS WILL DRIVE PAT PH-2

The verification and reporting cycle of phase-I of the PAT scheme finally ended on 17th August, 2015 and the industry is now awaiting the announcement of targets for the next cycle. An analysis[1] of the projects done by the Designated Consumers was carried as a part of this briefing series.

Highlights

- **Low cost retrofit projects dominated Phase-I**. Almost 65% of the projects fell in this category. The focus was primarily on driving utility and component efficiency rather than process and/or systems efficiency.
- More than 6**0% of projects carried out were relevant across sectors** (and not sector specific). There remains a potential for cross-sectoral learning that is likely to be tapped into in the next couple of years.
- Interviews with the Designated Consumers reveal that process innovation, availability of low cost finance and ESCerts trading hold the key to success of second cycle of PAT.

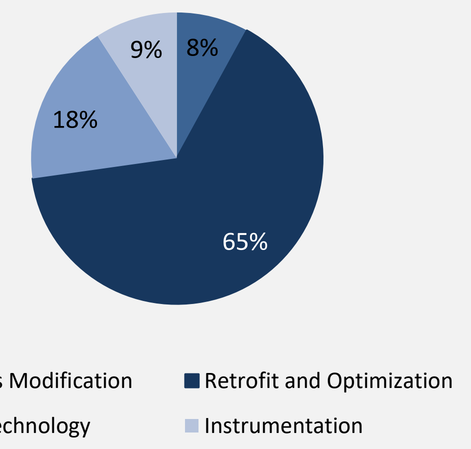
Most projects implemented by DCs in phase-I of PAT were incremental

In order to illustrate the better understanding of underlying trends influencing the sentiment and action of DCs, an analysis has been done regarding projects carried out by a sample of the Designated Consumers.

Out of the 426 projects assessed, almost 65% were focussed on retrofit and optimization. Mostly dominated by cement, aluminium and iron and steel sectors, these projects were primarily linked to utility operations, motors operations, upgrade of technology components, optimization in process parameters; retrofits in plant electrical & thermal utilities; up-gradation of technology components especially in drives (like energy efficient motors, use of VFDs etc.), air compressors, HVAC systems and pumps. Similarly, adoption of waste heat recovery projects in many sectors as an EE improvement option. We also observe that enhancement of capacity utilization of plant (or equipment) has impacted in resulting low SEC in many cases.

Broadly, it can be concluded that most of the low-hanging fruits were tapped in this class, which required low investments and had a short term pay-back.

Figure 1:Types of Energy Efficiency Projects undertaken in PAT phase-I



Source: Survey result, Sustainability Outlook-AEEE Analysis

[1] Sustainability Outlook and AEEE conducted a detailed survey with a sample of 47 Designated Consumers from the 8 PAT sectors

The focus was found to be more on component efficiency (which can be achieved by installation of individual components with guaranteed payback) rather than system efficiency.

This led to significantly less projects with major technology change in the first cycle of the PAT and so, only concentrated on harnessing the potential of low-hanging fruits with relatively less CAPEX.

For the purpose of this analysis, energy efficiency (EE) projects undertaken by the surveyed DCs under PAT scheme have been classified into four categories:

1. **Process Modifications:** These projects include changes in operating modalities of the process which leads to improvement in efficiency. Some of the actions include excess air control in fuel combustions, eliminating redundant / idle equipment operations etc. etc.

2. **Retrofit and Optimization:** The projects that require replacement of inefficiently operating technology by either energy efficient or newer component. For instance some of the PAT projects included introduction of variable frequency drives, rebuilding of coke oven and introduction of energy efficient computerised combustion control system for heating, chiller up-gradation with less steam consumption.

3. **New Technology:** These projects were linked to adoption of technological changes (either cross cutting or sector-specific installations). Some of the PAT projects under this category include commencing coal dust and coal tar injection in Blast Furnace, replacement of old open type motors with EE motors, changing from Soderberg to Pre-bake technology in Aluminum smelter, use of vertical roller mills in cement sector etc.

4. **Instrumentation and Control:** These include automated systems and management techniques deployed for monitoring and data collection for smooth and efficient operation of the processes. The project undertaken by the DCs under these categories are Thermo-compressor automation, up-gradation of meters, installation of oxygen analysers in the flue path of boilers, etc.

More than 60% of projects carried out were cross-cutting rather than sector specific

A significant proportion of the projects carried out in Phase-I were found to be cross-cutting with generic applicability rather than sector-specific. Almost 70% of the retrofit and optimization projects were cross cutting in nature and included installation of VFDs etc. Other technology focussed projects included adoption of energy efficient pumps, air compressors, burners and thermal insulation systems, waste heat recovery systems etc.

Table 1: Cross-cutting projects were about 65% of total projects surveyed

	Total Projects Studied	Cross cutting projects	Cross cutting as a % of total projects
Instrumentation projects	39	34	87%
Retrofit and Optimization projects	276	187	68%
New Technology projects	77	52	68%
Process modification projects	34	5	15%
Total	**426**	**278**	**65%**

Instrumentation and Control projects: Low adoption in Phase-I but high potential for replicability across sectors in phase-II

In the category of instrumentation more than 85% of the projects are cross-cutting, but their application in phase-I has seen one of the lowest adoption across all the 8 sectors covered under the PAT scheme. The table below illustrates the type of projects that are adopted by various sectors, but also has significant replicability potential in other sectors too.

Table 2: Cross-cutting instrumentation related projects that have a potential of replicability

Name of Cross-Cutting Instrumentation Projects	Sector of Adoption in Phase-I					
	Aluminium	Cement	Fertilizer	Iron & Steel	Pulp & Paper	Thermal
Installation of oxygen analysers in the flue path of fuel combustion process.	✓		✓	✓		
Implementation of automated process control in digestion and evaporation systems to reduce steam consumption.	✓					
Common Utility – PLC based compressed air system monitoring and automated control to save electrical energy.						✓
Automation of Hydro-cyclone for throughput improvement.		✓				
Power saving from rewinder BCP trim blower of motor					✓	
Commissioned HT & LT APFC panels to improve Power Factor.		✓				
Installation of multistep controllers in Raw Mills dust collector compressors for better control of outlet pressure.		✓				
Dust collector cleaning operation converted from timer based to differential Pressure based cleaning to avoid excessive cleaning and optimising compressed air consumption.		✓				
Regular monitoring by thermograph for all electrical feeders and panels to avoid breakdowns.		✓				
Continuous monitoring and elimination of false air to reduce fan power consumption and reduction in specific heat consumption in pyro-processing and grinding system.		✓				
Interlocking for condensate separator pumps with condensate level to reduce power consumption.					✓	

Key retrofit and optimization projects where cross-sectoral learning can play a role

As indicated above almost 70% of the retrofit and optimization projects carried out under PAT phase 1 were non-sector specific and can be leveraged across multiple sectors. The table below highlights some of the key projects undertaken by specific sector in the first cycle which lend themselves to cross sectoral applications. As per the survey, installation of Variable Frequency drives was one of the most dominant retrofit projects across all sectors in PAT Phase 1.

Table 3: Retrofit projects that have a potential of replicability

Cement	**Paper and Pulp**
• Installation of Medium/Low Voltage Variable Speed Drives in fan of bag filter fans and compressors, positive displacement blower, kilns, calciner compressor, mill vent fan, separator vent fan, dust collector fan, belt conveyors forced draft fans of cooler, and vacuum pumps. • Installation of waste heat recovery systems • Optimization of compressors	• Chiller upgradation with less steam consumption • Changing the TAP position of the lighting transformer • Vacuum Pump optimization • Installation of VFD for hood blower, steam feed water pump, stoker motor, secondary sludge pump etc.
Iron and Steel	**Textile**
• Rebuilding of Coke oven Battery and introduction of energy efficient computerised combustion control system for heating • Waste heat recovery from sinter cooler • Thermal insulation of steam lines • Improvement in bath temperature by replacement of heat exchanger tubes • Installation of Variable Voltage Variable Frequency (VVVF) drives	• Installation of Variable frequency drives for boiler accessories (like FD/ID fans, FW pumps), Thermic Fluid Heaters, cooling fans • Modification of exhaust ducting of compressors to increase efficiency of compressor • Modification of compressed air piping by arranging air flow meter separately to reduce pressure drop • Adoption of module wise lighting
Aluminium	**Fertilizer**
• Low pressure blower runtime optimisation • Modification in Induced Draft Fan • Optimization in Electrostatic Precipitator, Compressor • Installation of VFD in pumps and fans • Reduction of diesel consumption in production vehicles by improving engine efficiency	• Installation of VFD in boiler feed water pumps, waste collection system, ammonia feed pump

Actions and outlook of Designated Consumers (DCs) in the sectors surveyed

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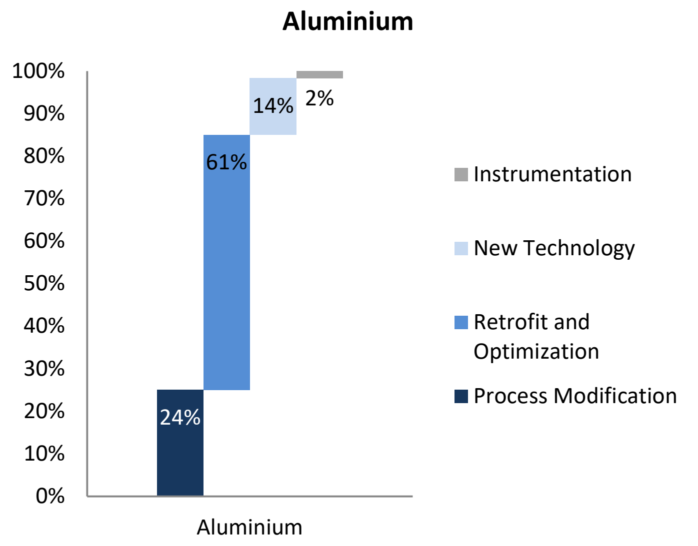
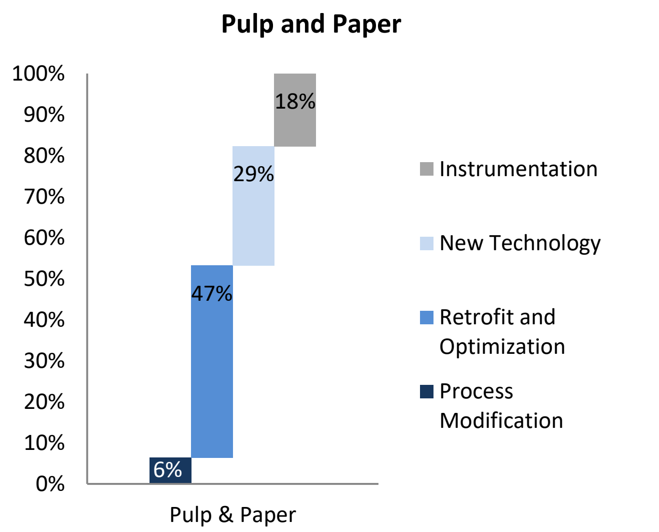
<tr><th>Types of projects done in Phase I</th><th>Actions and outlook of DCs surveyed</th></tr>
<tr><td>
</td><td>The Aluminium sector, introduced new in-house technologies (such as CRYSTAL additive for dosing inside furnace by Hindalco, use of slotted anodes by NALCO) which have come to be regarded as best-in-class among its various industries.

However, considering the long time required for in-house R&D activities, capacity ramp-up and reaping the benefits of EE projects, a few DCs are found to have made a pitch for increasing the cycle duration for the second phase of PAT.

The aluminium sector had the most number of process modification projects as compared to other sectors.</td></tr>
<tr><td>
</td><td>Paper and Pulp sector saw a significant adoption of energy efficient pumps and motors. This sector also had the largest sectoral share in instrumentation projects with 14 out of the total 27 such surveyed projects being carried out here.

Almost 80% of all the projects assessed for this sector were cross-cutting in nature.

With increased use of renewables through bagasse based/black liquor based energy generation, the paper and pulp sector has been vying for getting dual benefits of RECs and ESCerts.</td></tr>
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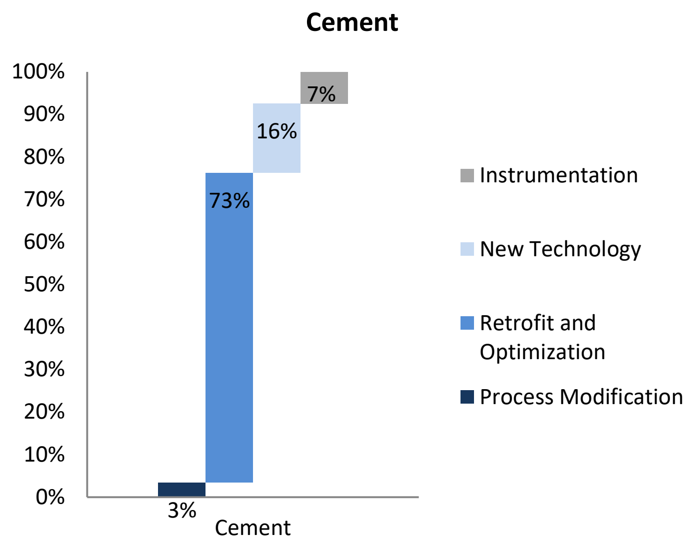
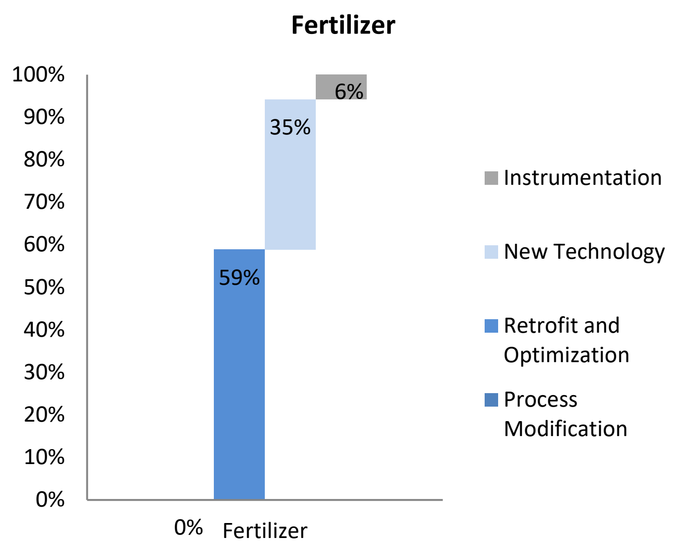
<tr><td>
</td><td>Even though the Indian cement industry is amongst the most energy efficient in the world, the focus was found to be more on retrofit and optimization projects.

64% of the total projects assessed for this sector are cross-cutting across sectors. Low and Medium Voltage VSD and VFD, Energy efficient fans and motors are some of the generic interventions which form a major chunk of the optimization projects. DCs in this sector were predominantly categorized by large cash rich companies who have mostly used internal accruals to finance energy efficiency projects in Phase 1 of PAT.</td></tr>
<tr><td>
</td><td>Energy efficiency activities in industries in the fertilizer sector are largely driven by pre-set energy consumption norms (5.5 GCal/MT, 6.2 GCal/MT and 6.5 GCal/MT[2] are the set targets for 2018-19 for Group I, II and III companies respectively) which are required to be met in order to access government subsidy.

As it is a mandatory requirement for the Fertilizer industries to report the technical operating data to Fertilizer Industries Co-ordination committee (FICC), adoption of state-of the-art MIS/Energy Management systems is a necessity rather than a choice, which is evident in the high off-take of DCs and advanced process control systems in fertilizer industry. Owing to the stronger policy push outside of PAT scheme, the sector feels the scheme adds to its burden of reporting and doesn't incentivize it to adopt energy efficiency practices beyond the existing targets set for it by the government.</td></tr>
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[2] http://fert.nic.in/sites/default/files/New%20Urea%20Policy%202015%20for%20exixsting%20based%20urea%20manufacturing%20units.pdf

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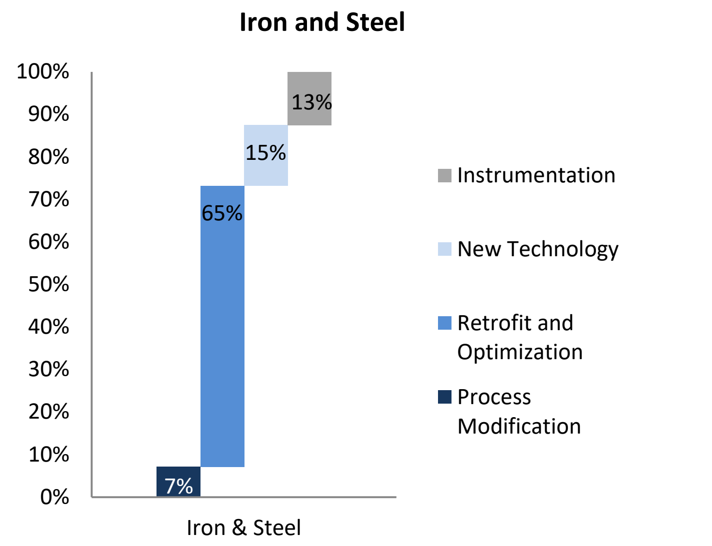

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The Iron and Steel industry has to be competitive in the Global market for its products to sell: hence increasing efficiency to beat global standards is another key driver.

The response from DCs indicates that owing to the high investment (ranging from Rs 2 Cr to Rs 40 Cr) and lengthy payback times up to 45 months associated with making major technology changes; most projects have been limited to retrofits. The willing to pay penalties for not achieving their targets was highest in this sector.

The DCs indicated that the sector is yet to figure out a breakthrough technology which will lead to a significant reduction in its specific energy consumption. Most projects in future would remain incremental in nature.

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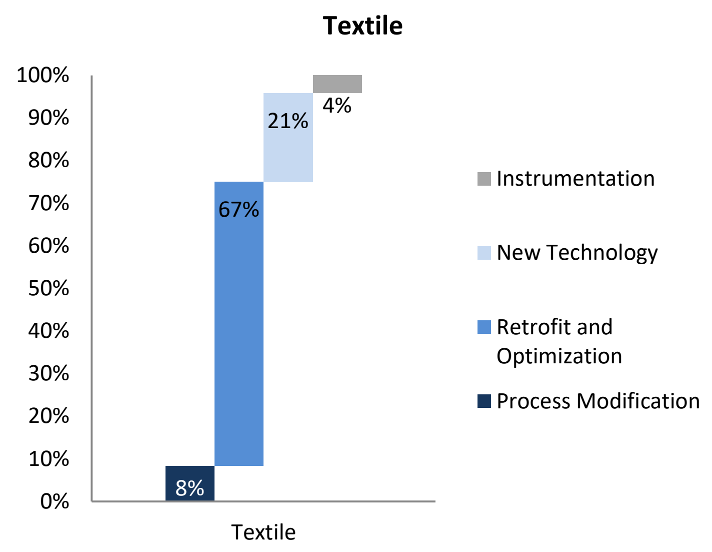

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Retrofit and optimization project dominated the textile sector in PAT phase 1 with installation of variable frequency drives (VFDs) having a significant share in the mix.

Long term projects are not found to have been taken up in spite of the size of investment required being relatively lower than other sectors.

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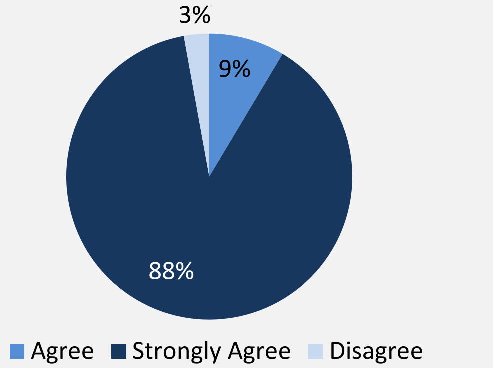
What DCs thought of the M&V process

To a great extent, the effectiveness of PAT depends on the robustness of the Monitoring and Verification (M&V) protocol. The M&V protocol serves many purposes such as identification of controllable and uncontrollable variables, assessment of data and information need for monitoring of the variables, development of data & information protocol, development of regression equations and normalization methodology , development of systems for information flow in line with Bureau of Energy Efficiency (BEE) laid out criteria (Transparency, Acceptability, Measurability, Traceability & Verifiability) and development of organisational & institutional framework for management of the M&V process for the key stakeholders.

Figure 2: Survey response from DCs on transparency of M&V process

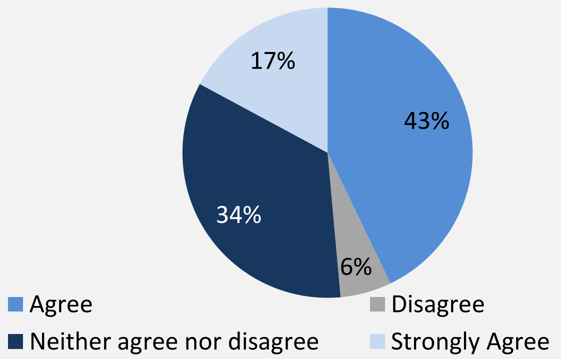


Source: Survey result, Sustainability Outlook Analysis

The survey response obtained from DCs indicated that the M&V design and process was transparent, They shared that this was enabled by extensive stakeholder consultation workshops conducted at regular intervals and handholding by the technical sub-committees for each sector.

However, given that 478 DCs had to be audited by 53 M&V agencies, the time of 3 months allotted for carrying out M&V was largely regarded as insufficient across all the industrial sectors, a fact which is also corroborated by anecdotal responses obtained in our survey. The additional factor that also affected was due to the delay caused in the duration of completion of M&V process itself, which only completed in mid-August 2015.

Figure 3: EmEAs level of familiarity with the job



Source: Survey result, Sustainability Outlook Analysis

More than 50% of the survey respondents agreed that the M&V agencies had desired level of capabilities to carry out the process. Some respondents indicated that sometimes there were differences in the interpretation of BEE guidelines by M&V agencies and lack of clarity/non-inclusion of normalization factors. Some of the sectors, Fertilizer in particular faced issues due to difference in accounting methodologies used conventionally (box approach) versus those used under the PAT scheme (gate-to-gate approach) to report their energy performance. According to the DCs, few normalization factors in which they lacked clarity included fuel quality in cogeneration plant, membrane ageing factor, product mix and intermediary product and biomass and alternate fuel availability.

What DCs are thinking: Process innovation, Availability of low cost Finance and ESCerts trading hold the key to success of second cycle of PAT

Availability of benchmarkable data can be improved through automated data management systems

The survey indicates that a significant proportion of the DCs were lacking in terms of benchmarkable and quality data related to their energy performance which is not only beneficial from a compliance standpoint but also drives idea generation and in-house innovation within an organization. Though 97% of the Designated Consumers surveyed indicated that they had a formal mechanism – energy management systems (EnMS) in place for tracking of energy efficiency related projects, only 43% of these organizations had fully automated /partially automated systems of monitoring and tracking projects and timely reporting systems, such as Digital Control Systems and Advanced Process Control systems. According to BEE estimates, around 200 Designated Consumers were expected to take up ISO 50001certification during the year 2014-15. This is expected considering PAT industries already fulfill majority of the prerequisites of ISO 50001 standards (such as plant boundary fixation, establishment of energy performance indicators and targets, normalisation of assessment year operating conditions with base line year etc.)

In the Cement and Fertilizer sectors, which constitute a major percentage of India's total industrial energy consumption, process innovation is the only way to avoid being penalized in the second cycle of PAT, as the performance as well as technology aspects are already best in the world. Process innovation is of no less importance in the Iron and Steel sector, in which BAT implementation projects as well as Retrofits have not happened to the extent desired due to high investment requirement and layout constraints respectively. Clearly, high quality R&D leading to disruptive process innovations and their quick mainstreaming is the need of the hour going in to the second cycle of PAT. In that context, incubating early stage technologies and carrying out demonstration programmes by catalyzing private sector co-investment into pre-commercial technologies could play a pivotal role by in the coming years.

An important reason that has emerged for the low adoption of BATs throughout all the sectors is the non-availability of low interest loans which makes the case for exploring green bonds as an alternate route (as suggested by a few DCs and financial institutions) even stronger. **Inclusion of non-energy benefits of energy efficiency projects**, which is a relatively nascent concept that is yet to gain traction in India, could also reduce the payback periods and help secure management buy-in. These benefits, which include productivity gains, improved product quality, lower non-energy operating costs, longer equipment life, reduced maintenance costs, less waste generation, better resource efficiency, improvement of workplace conditions and pollution reduction would make a significant percentage of stalled projects more palatable to the management in industries. Enhanced capacity of plant personnel is already getting recognized as one of the indirect/non-energy benefit linked to PAT. Respondents in our survey shared that the process of engaging employees across departments in an organisation and tapping their creativity to meet energy savings goals has spawned increasing number of in-house innovations. The above cases also illustrate that some sectors are looking at adopting innovative technologies that are cost-effective in nature and that have short to medium –term return period.

Enhanced capacity of plant personnel is already getting recognized as one of the indirect/non-energy benefit linked to PAT

Risk Analysis of Energy Performance Contracting projects needed to improve the take-up of ESCO model

A significant majority of the DCs surveyed indicated that they had implemented the projects themselves rather than outsourcing the same to ESCOs which is an over-arching trend across all the sectors. The outlook for ESCOs remains grim amongst the surveyed DCs indicating lack of clarity about revenue sharing and credibility as the key issues. Financial Institutions surveyed during the survey stated the lack of knowledge on project risk, mismatch between ESCO size and project size and lengthy dispute resolution process as the aspects which need to be worked on collectively by the stakeholders to improve the climate for ESCO model in the second cycle of PAT. This subject will be delved in more detail in the upcoming brief of this series, which is focussed on ESCO model and financing challenges and learning during the first phase of the PAT; also looking at the opportunities that lie ahead for the second phase.

Accounting of PAT benefits in second cycle contingent on the smoothness of ESCerts' trading process in Phase-I
With regards to EScerts, the DCs response indicated need for clarity on EScert allocation in case of plant expansion, EScert allocation for new entrants in phase-II, status of EScerts in case of Mergers and Acquisitions, tax and accounting treatment of EScerts, netting and bubble provisions and cost basis of sold EScerts. DCs belonging to the Pulp and Paper sector have made a call for a provision in the Energy Conservation Act to avail the benefits of both Renewable energy Certificates and EScerts.. One of the next series will also cover the experience and market pulse of the EScerts market and trading mechanism, once operational.

Way forward

Overall, the DCs' sentiment from this survey gives mixed sense for the second cycle of PAT, with majority of them acknowledging the need and benefits of carrying out energy efficiency projects and yet on the look-out for incentives to aggressively push such measures in the expectedly stringent second cycle of PAT.

The survey also unveiled several opportunities. Key among them are:

1. Opportunities for cross-sectoral learning especially for instrumentation and retro-fit projects.
2. Need to make benchmarks widely available; which in-turn have an ability to accelerate the pace of adoption of efficiency measures

Working of the ESCert trading mechanism and financing models for energy efficiency projects continue to remain a key area of uncertainty[3]. The upcoming briefs of PAT Pulse will delve deeper into some of these areas. The AEEE-Sustainability Outlook working group on Industrial Energy Efficiency will also be putting together workshops on cross-sectoral learnings from PAT Phase 1.

[3] As on 6th August 2015, in terms of preparatory work for the trading phase of EScerts, roles and responsibilities of entities and EScert exchange regulations have been finalized, value of 1 EScert has been determined and manuals on Penalty and Adjudication process as well as Business procedures for EScert exchange have been prepared. These actions are expected to ensure the smoothness of the trading phase.

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)[4], provided estimates of the "probable magnitude" of energy efficiency market which pegged it at greater than **300 Billion USD.**

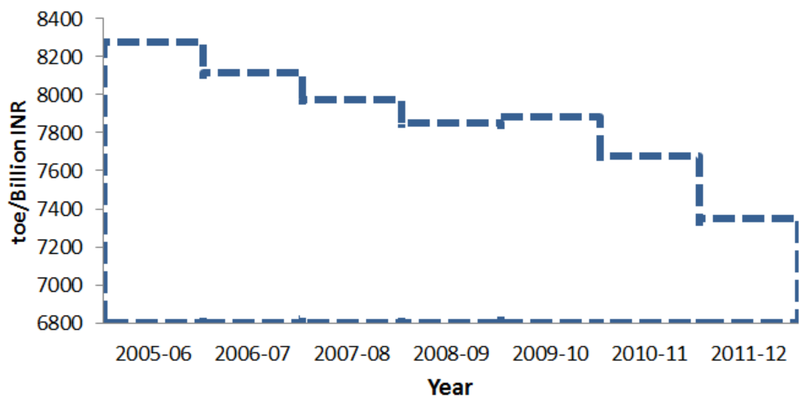
The Intended Nationally Determined Contribution (INDC) target committed by India at COP 21 in Paris to reduce its emission intensity by 33-35 percent from 2005 levels by 2030 would require energy efficiency investments to be a major driver on the demand side. Energy demand in India is expected to grow at Compounded Annual Growth Rate (CAGR) of nearly 4 percent by 2030 (from 2013)[5]. 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 1**Error! Reference source not found.** which shows that Indian manufacturing is steadily becoming less energy intensive.

[4] Energy efficiency Market Sizing Report, 2014, IEA
5 India Energy Outlook, World Energy Outlook Special Report 2015, IEA

Figure 4: Energy Intensity of Manufacturing GDP – India

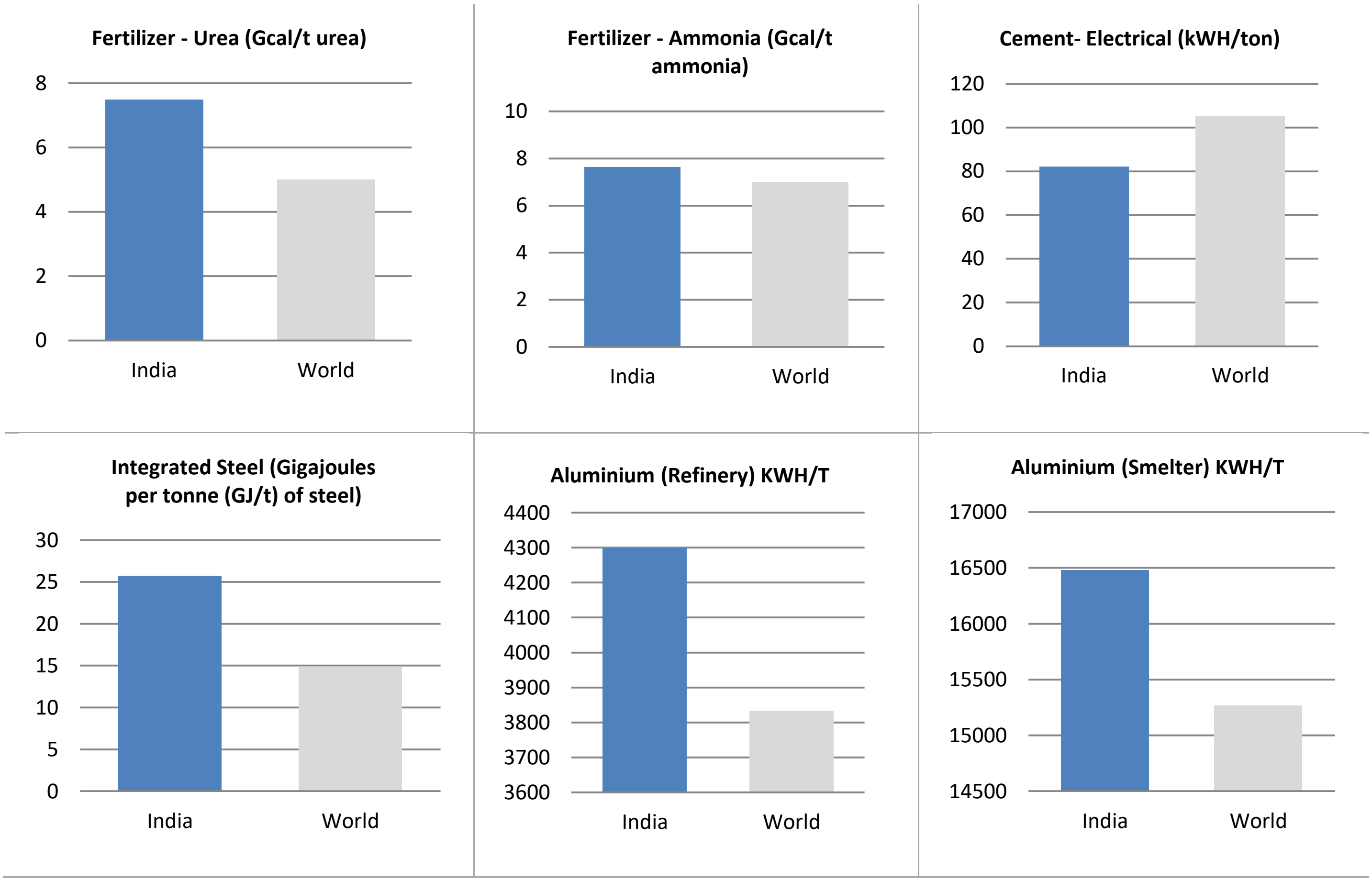


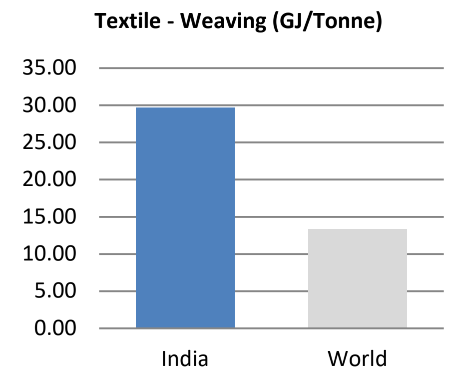
Source: Sustainability Outlook estimates compiled from Handbook of Statistics (RBI), International Energy Agency (IEA)

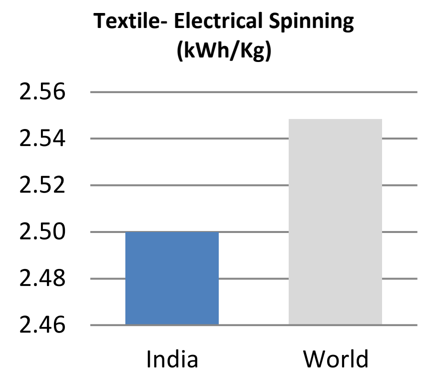
If we compare the average Specific Energy Consumption (SEC) of Indian companies with the current global best (Figure 2), it can be seen that the Indian firms still have scope for efficiency improvement apart from a few sectors such as cement with Indian manufacturing units are ahead. Sectors such as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

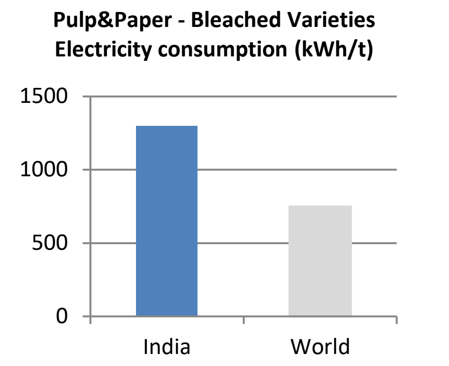
Informed policy making would entail setting prudent and achievable targets for energy efficiency interventions, and tracking the progress against those targets, which necessitate an understanding of the true potential of Energy efficiency markets.

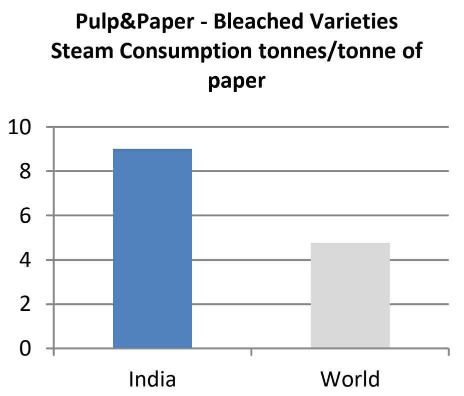
Figure 5: Specific Energy Consumption – India average vs Global best

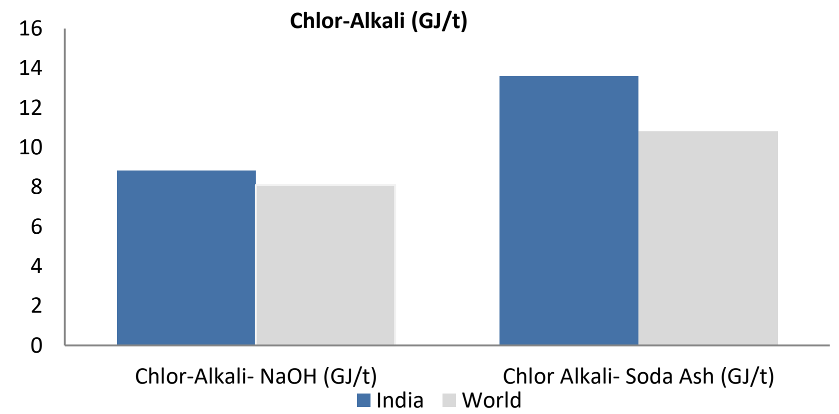












As is evident from above, there exists a significant potential for industrial energy efficiency improvements in India. In order to quantify this in a meaningful and actionable manner, Sustainabiliy Outlook and AEEE have created a detailed model to size the investment potential of energy efficiency interventions 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)[6].**
- **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[7].

[6] Assumption: 1 USD = Rs 65
[7] 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

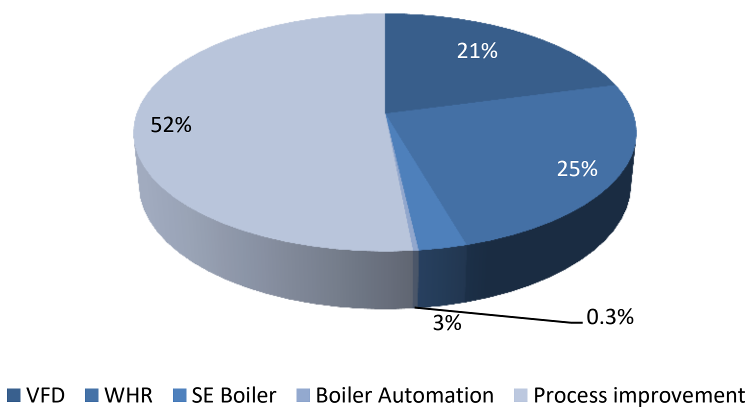
- **2016**: The **Bureau of Energy Efficiency** prepared its estimates for Energy Efficiency investments in the first cycle of PAT which were **US$ 3095 million (~Rs 20,000 crores)[8].**

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 6: 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.

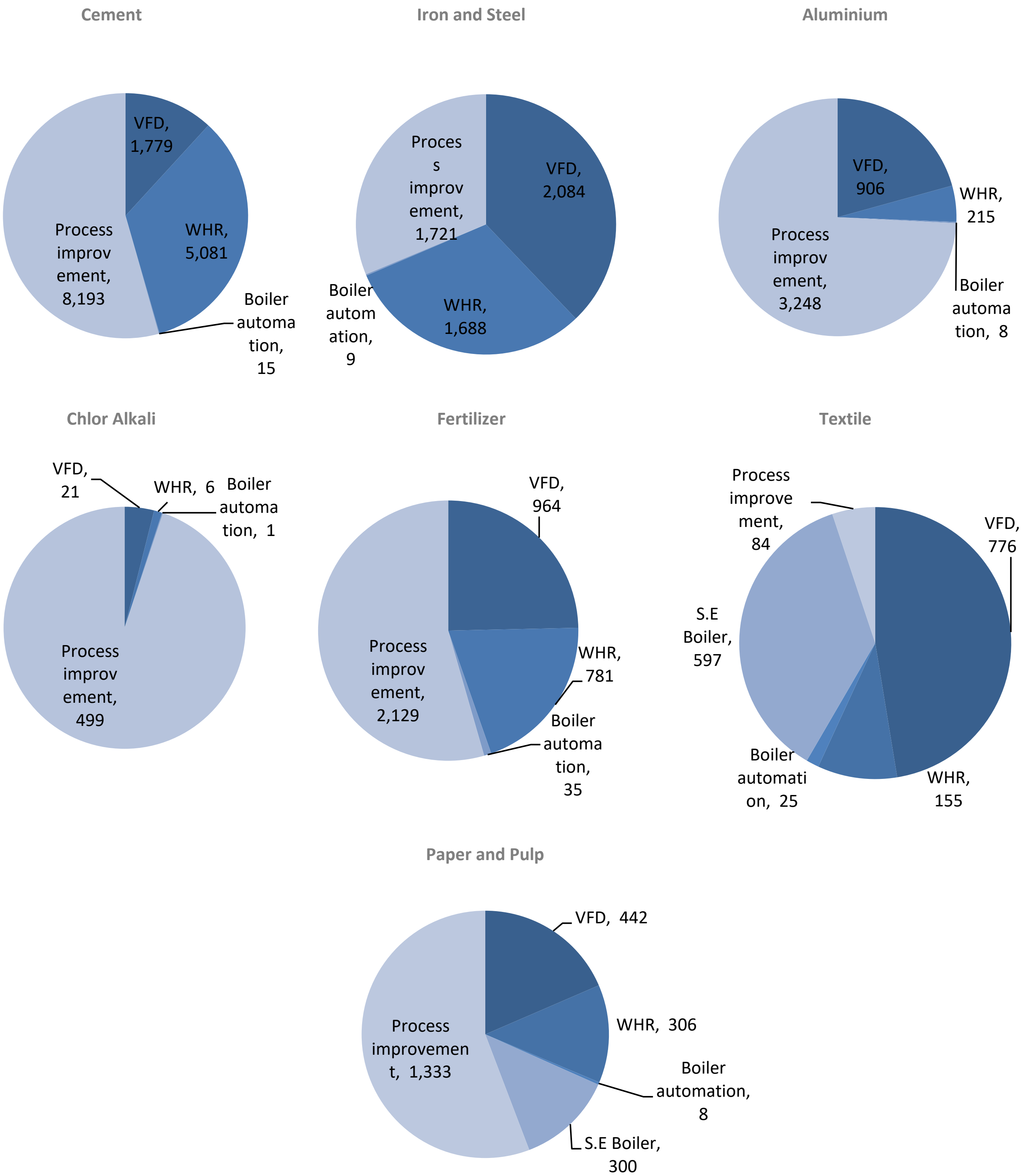
It was gathered through stakeholder consultations that certain interventions would be cross-sectoral and are likely to be amongst the thrust areas for multiple sectors under the upcoming phase of the PAT scheme. It was gathered that technologies such as Variable Frequency Drives (VFD), Waste Heat Recovery (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.

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

Figure 7: Sector wise investment potential (Rs crores)



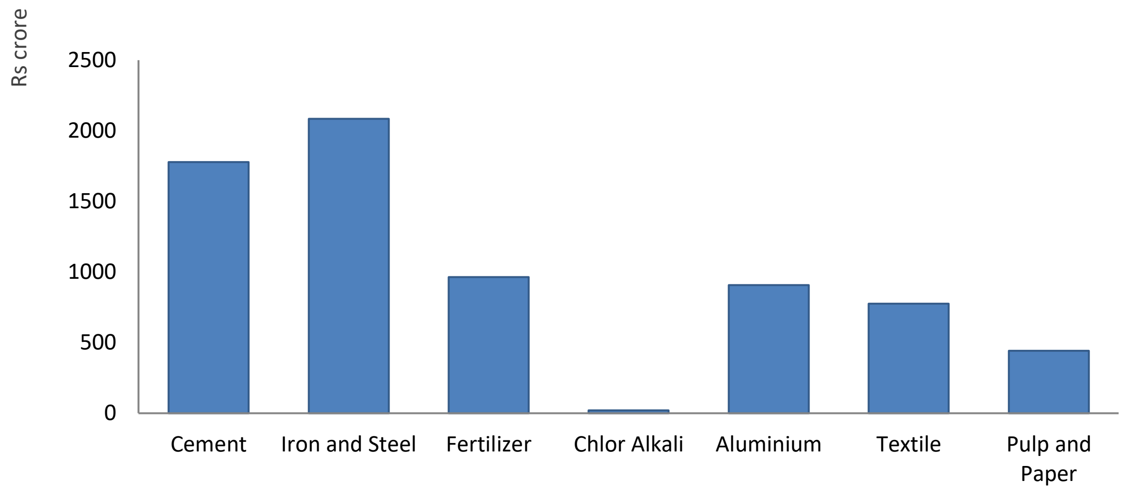
Source: Sustainability Outlook – AEEE analysis

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 8: 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 [**649º**C] and higher
Medium temperature WHR: 450ºF [**232ºC**] to 1,200ºF [**650ºC**]
Low temperature WHR: 450ºF [**232ºC**] and lower

Table 4 lists technologies which can be potentially used for heat recovery in the industrial sectors as per the grade of heat available.

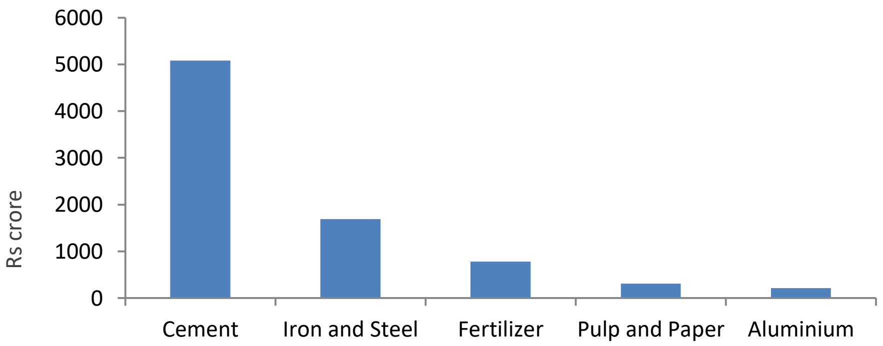
Table 4: Grades of Heat recovery and corresponding technologies

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 9: Sector wise Investment Potential of WHR technologies - All grades



Source: Sustainability Outlook – AEEE analysis

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**.

Process Integration means combining Needs/Tasks of "**opposite**" kinds so that **Savings** (or Synergies) can be obtained [9]

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

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

Policy has incentivized adoption of WHR in Industry

States such as Rajasthan[10] 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[11], all Sponge Iron Plants of capacity more than 100 TPD kilns shall install Waste Heat Recovery Boiler (WHRB) for power generation.

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[9] Truls Gundersen, Department of Energy and Process Engineering, Norwegian University of Science and Technology (NTNU) Trondheim, Norway

[10] http://rerc.rajasthan.gov.in/cnpl/PDFs/REC.pdf

[11] http://www.cpcb.nic.in/divisionsofheadoffice/pci2/CREPspong&other.pdf

Table 5 highlights some of the key areas of recovering waste heat from different processes/equipment across multiple sectors as per the temperature category.

Table 5: 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.[12]

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

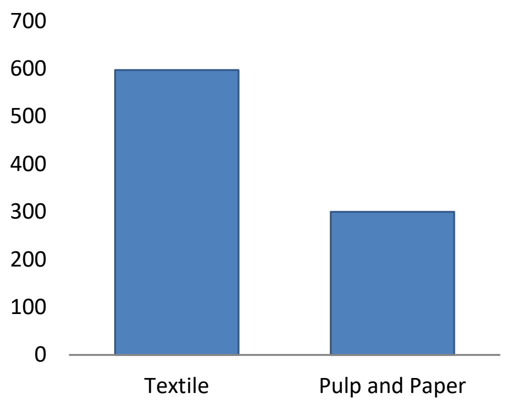
Different types of WHRBs supplied for different applications by Indian manufacturers

- 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

[12] 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

Figure 10: Investment Potential Super-Efficient Boilers - Rs 900 Crores



Super-efficient boilers are a priority area for process industries such as textile and paper and pulp sector which need steam for process heating.

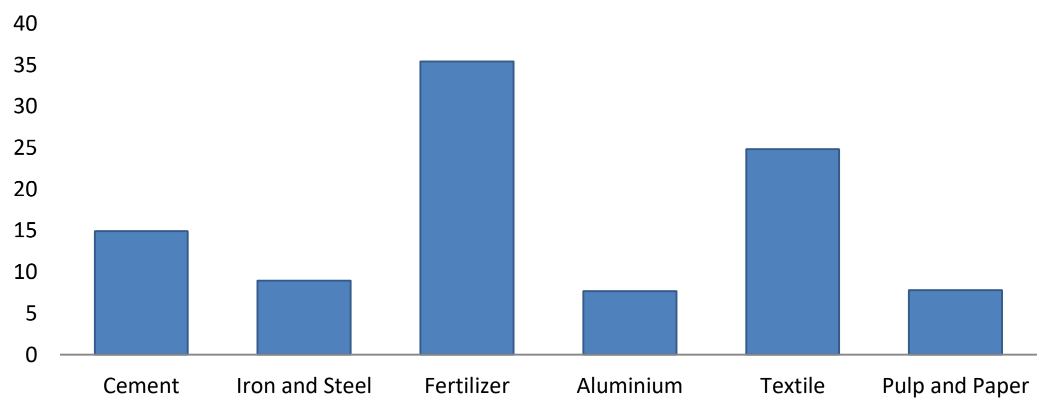
Focusing on these two sectors only, t**he overall market for super-efficient boilers which is realizable by 2020 has been estimated to be Rs 900 crores with textile sector accounting for 67% of the total estimate** (Figure 7).

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 11: Estimated Investment Potential for Boiler Automation



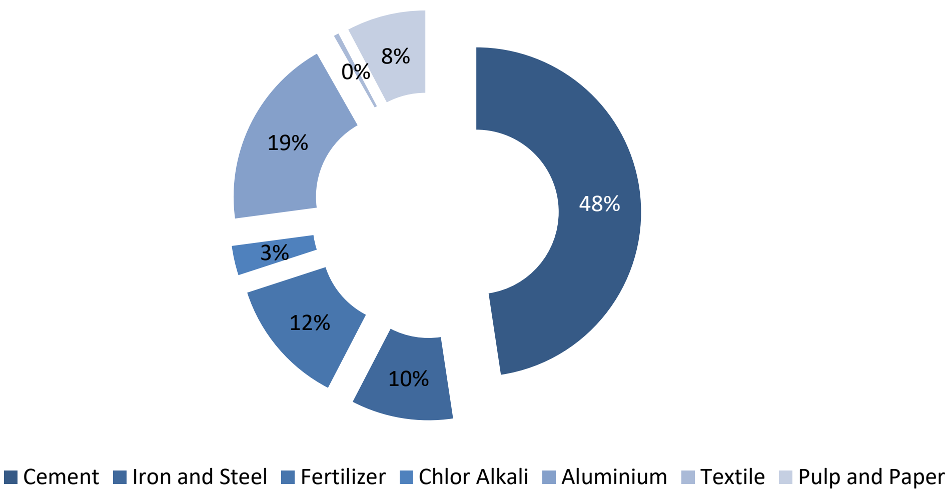
Source: Sustainability Outlook – AEEE analysis

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

As discussed in our January 2016 issue of PAT Pulse, 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 12: 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 recti formers (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

Key Challenges for increasing penetration of EE interventions in the industry

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

- **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.

- **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 versus 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)
- Aluminum: 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

FINANCING ENERGY EFFICIENCY IN INDIA: WHO WILL INVEST?

Highlights:

- Two key determinant of the financing patterns are:
    - Size of the Designated Consumer (and/or its parent). Those with fixed assets of Rs. 500 crore and above have been classified as "large"; and others are small.
    - Whether companies will put in their share of contribution as part of the overall financing; or expect 3rd parties to do so.
- Cross-cutting Technologies (e.g. VFDs, Waste Heat recovery, etc. that cut across industries) have maximum potential for Vendor finance/ESCO model
- Projects in Chlor-Alkali and Aluminium sector can account for maximum financing through project specific term loans whereas Cement and Fertilizer can get clubbed with loans within existing lines of credit
- Policy push and standardization in EE projects are key levers to realize the investment potential

Financing Industrial Energy Efficiency: a challenge, really?

The techniques and technologies to improve industrial energy efficiency have been well proven but a notable challenge for policy makers is to accelerate their adoption. PAT (Perform Achieve trade) scheme is definitely a positive step in this direction but Indian industry still has a fair ground to cover. Sustainability Outlook and AEEE engaged multiple stakeholders including industry (PAT Designated Consumers), financial institutions as also Energy Services Companies (ESCOs) to understand the current state of industrial energy efficiency financing. Discussions revealed that typically a low budget is allocated for energy efficiency projects by industries who undertake most projects with short term payback (less than 3 years).

Some of the key challenges for energy efficiency as faced by three distinct segments- the ESCOs, Banks and the DCs include:

Industry	• Unwillingness to prioritize Energy Efficiency. Investments more driven by growth and revenue enhancement rather than cost savings. • Validation of actual savings realized from energy efficiency projects; lack of standardization a key impediment
Financial Institutions	• Lack of enforcement of performance contracts for energy efficiency projects • Difficulties in measurement and verification (M&V) of energy efficiency • Lack of standardized project documentation and appraisal procedures • Lack of awareness and experience among banks for types of EE projects • Limited availability of collateral for project financing • Low ticket size of investment for the energy efficiency projects
ESCOs	• Weak balance sheet of most ESCOs • Lack of demonstrability/track record • Lack of capacity: perceived limited understanding and limited capacity of sector specific processes • Lack of standardized measuring and verification systems • Litigation process costly and time consuming for non-compliance with performance contracts

Discussions with multiple stakeholders revealed that there is a need to demystify the financing landscape of industrial energy efficiency (EE) in India and understand the current lacunae (if any) in terms of instruments required for financing this domain in the Indian industrial sector.

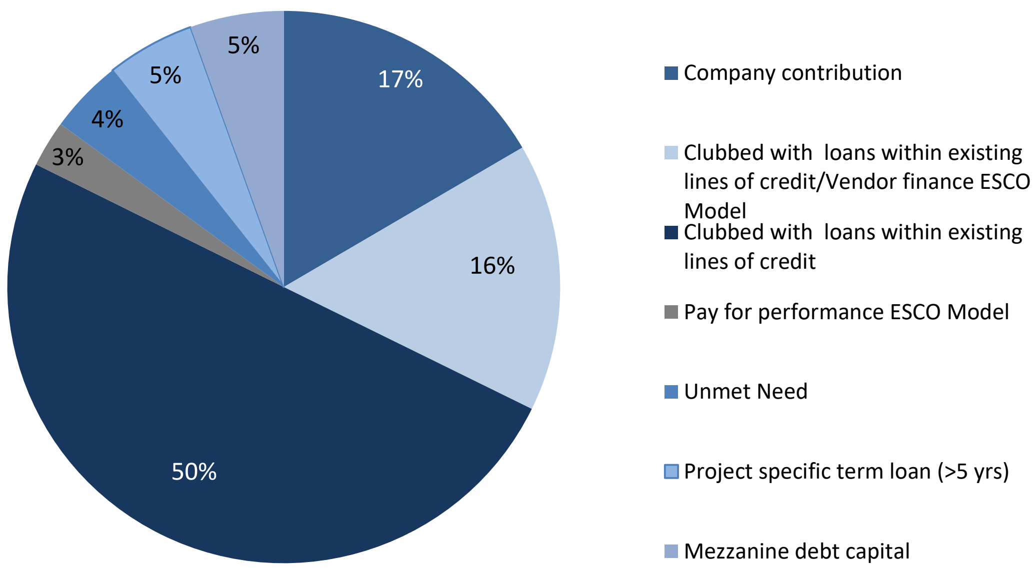
All the stakeholders - Policy makers, Industries, Financial Institutions and Service Providers/ESCOs have varied approaches to financing energy efficiency and need of the hour is to determine the common direction which will satisfy the requirements for all of them and leap frog industrial energy efficiency market in India.

In a bid to establish this common direction, based on extensive discussions with the stakeholders, Sustainability Outlook and AEEE have developed a framework to assess sources of capital that are likely to finance industrial energy efficiency in India in the near term.

Out of the total investment potential presented by industrial energy efficiency in the 7 sectors covered under PAT Phase 1 (excluding thermal power sector) - estimated to be approximately Rs. 34,000 crore (USD 5bn) by 2020 (refer May 2016 issue of PAT Pulse), 17% or approximately Rs 5,500 crores (USD 0.8 bn) would be required as company contribution /equity/margin money. The remaining 83%, i.e Rs 27,000 crores (USD 4.2bn) can have multiple financing routes including:

1. Project Specific Term Loan (>5 yr tenure)
2. Clubbed with loans within existing lines of credit
3. Vendor finance ESCO model
4. Pay for Performance ESCO model
5. Mezzanine Debt Capital

Figure 13: Break-up of the total investment potential (Rs 34,000 crores) (USD5 bn) in industrial EE for PAT sectors (excluding thermal) as per likely financing routes



Source: Sustainability Outlook and AEEE analysis

However, currently the key challenge is unwillingness of many companies to invest equity in savings projects such as those linked to energy efficiency instead of growth projects which will enhance the top line performance. The table below provides a detailed break up of sources of financing as per intervention type and sector.

<table>
<tr><th>Financing route</th><th>Type of Interventions</th><th>Financing need (Rs crores)/(USD mn)</th></tr>
<tr><td rowspan="3">Clubbed with loans within existing lines of credit</td><td>Cross-Cutting Technologies
• DCs where VFD and WHR account for significant proportion of overall capex and DCs balance sheet is strong
• Super-efficient Boilers for large DCs (fixed assets>Rs 500 cr)</td><td>Rs 5,764 Cr (USD 873 million)</td></tr>
<tr><td>Process interventions (with short term/<3 yr payback)
• Textile - High Speed Carding Machine
• Aluminium - Seal Pot System for Condensate Recovery; Slots in the anode
• Pulp & Paper -Installation of Extended Delignification System for Cooking of Wood
• Fertilizer - Vapour Absorption System, Retrofitting Steam Turbines for Higher Efficiency
• Chlor-Alkali - Ion exchange membrane cell process
• Cement - Vertical roller mills; Use of EAF Slag; Clinker cooler retrofits; use of flyash</td><td>Rs 5,761 Cr (USD 873 million)</td></tr>
<tr><td>Process interventions (with medium term/3-5 yr payback)
• Cement - High efficiency clinker coolers
• Fertilizers - Vapour Absorption System; Two Stage Regeneration in CO2 Removal System; Adiabatic Pre-reformer
• Pulp & Paper - Firing of Black Liquor at High Concentration
• Iron and Steel - Waste Heat recovery from sinter bed; Coke Dry Quenching</td><td>Rs 5,162 Cr (USD 782 million)</td></tr>
<tr><td>Clubbed with loans within existing lines of credit/Vendor finance ESCO Model</td><td>• VFDs across sectors where the investment is not significant proportion of overall capex</td><td>Rs 5,235 Cr (USD 793 million)</td></tr>
<tr><td>Pay for performance ESCO model</td><td>• Textile and Pulp & Paper- Super efficient Boilers for small DCs (fixed assets<Rs 500 cr)
• WHR for small DCs (fixed assets<Rs 500 cr)</td><td>Rs 909 Cr (USD 138 million)</td></tr>
<tr><td>Project Specific Term Loan (>5 yr tenure)</td><td>• Chlor-Alkali- Anode and Membrane replacement along with Zero gap conversion of Electrolyser
• Aluminium-Inert anode (PBANOD) in Hall Heroult Process</td><td>Rs 1, 722 Cr (USD 261 million)</td></tr>
<tr><td>Mezzanine Debt Capital</td><td>• DCs where VFD and WHR account for significant proportion of overall capex and DCs balance sheet is stretched</td><td>Rs 1, 800 Cr (USD 277 million)</td></tr>
<tr><td>Unmet Need</td><td>• Chlor-Alkali: Anode and Membrane replacement along with Zero gap conversion of Electrolyser
• Aluminium: Inert anode (PBANOD) in Hall Heroult Process</td><td>Rs1400 cr (USD 218 milion)</td></tr>
</table>

Source: Sustainability Outlook and AEEE analysis

50% of the investment potential can be financed by getting clubbed with loans within existing lines of credit

Out of the total financing potential of Rs 34,000 crores (USD 5bn), 50% or about Rs. 16,600 crore (USD 2.5bn) can be financed by loans within existing lines of credit.

About 16% or ~Rs 5,200 crore (USD 800m) could be financed either by existing credit lines or through vendor finance ESCO Model depending on the preference of the DC undertaking the intervention. If the DC has the ability to bring its (equity) contribution to the project, then it is likely to get financed through existing lines. Otherwise it would get financed through vendor financed lines/ supplier credit.

5% or Rs1700 crores (USD 260m) from the remaining can be supported by project specific term loan (with greater than 5 year tenure), about 5% or Rs 1800 crores (USD 277m) through mezzanine debt crores and about 3% of the total investment potential, i.e Rs. 909 crores (USD 140m) exclusively through Pay for performance ESCO model. As per our estimates, about 4% or Rs 1400 crores (USD200m) of financing need maybe unmet with the existing financing options.

Clubbing with loans within existing lines of credit is the most optimal route for financing energy efficiency interventions in case:

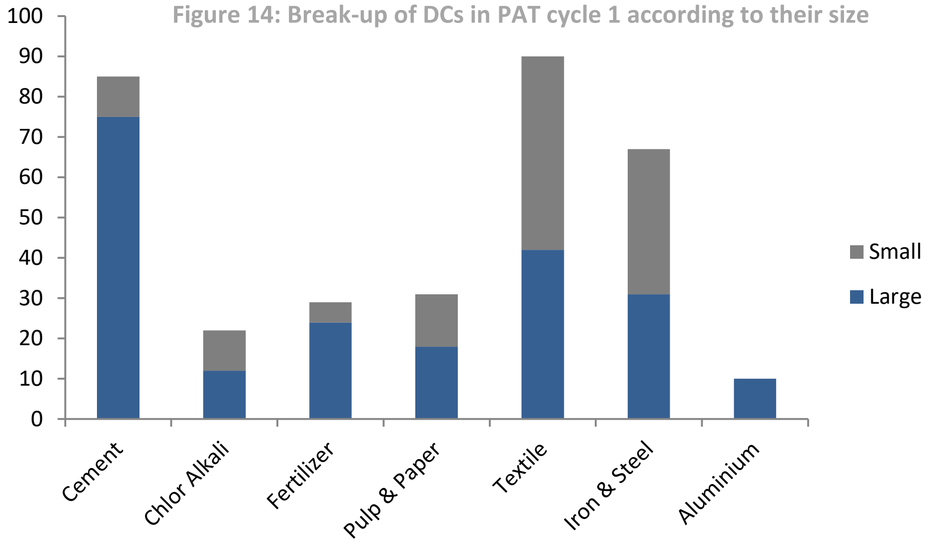
1. The intervention under consideration is process linked to process improvement which does not account for a significant amount of capex (compared to total capex of the firm) and has a short term payback (less 3 years)
2. The intervention is a cross cutting technology, with short term (less 3 years) or medium term (3-5 years) payback, and savings from the intervention are measurable.

For sectors such as Cement, Fertilizer, Iron and Steel, most of the interventions considered for the purpose of this analysis are likely to be completely financed by getting clubbed with loans within existing lines of credit which the DCs may be using as they fall in either of the two categories as stated above.

Large DCs likely to fund EE through Internal accruals but Vendor/ESCO route promising for small DCs

The choice of likely financing route is significantly impacted by the size of the firm/DC under question. For this analysis, if the fixed assets of a DC are more than Rs. 500 crore, it has been classified as “large”. Based on this classification, the figure below provides a sector wise break-up of the DCs in terms of size.

Figure 14: Break-up of DCs in PAT cycle 1 according to their size



While 212 of the total 334 DCs (excluding thermal power plants sector) considered in this study are large, remaining 122 are small DCs. The maximum number of large DCs are in the Cement sector (75 out of the total 85 DCs) and the minimum small size DCs in case of Aluminium sector (none of the 10 DCs included are small in size). In contrast, there is almost an equal division between the large and small sized DCs in the Iron & Steel, Textile, Pulp & Paper and Chlor-Alkali sectors.

Within the large DCs, those with large balance sheets, who have strong existing relationships with banks, the most likely and optimal route for energy efficiency interventions is clubbing the financing requirements with existing lines of credit. While this route can account for upto 53% or about Rs. 16,000 crore of the total Rs. 25,400 crore investment potential for large DCs, the remaining investment potential can be potentially split across project specific term loans (>5 yrs tenure) (5%) and mezzanine debt capital (6%). Around 3% remains unmet for large DCs. About Rs 4700 crores or 15% of the total financing requirement may be either met through vendor finance ESCO model or clubbed with existing loans depending on the preference of the DCs.

Figure 15: Large DCs- Potential financing routes for EE interventions

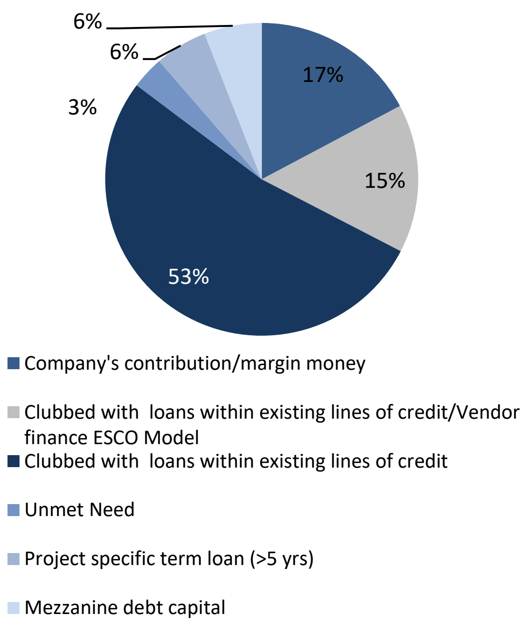
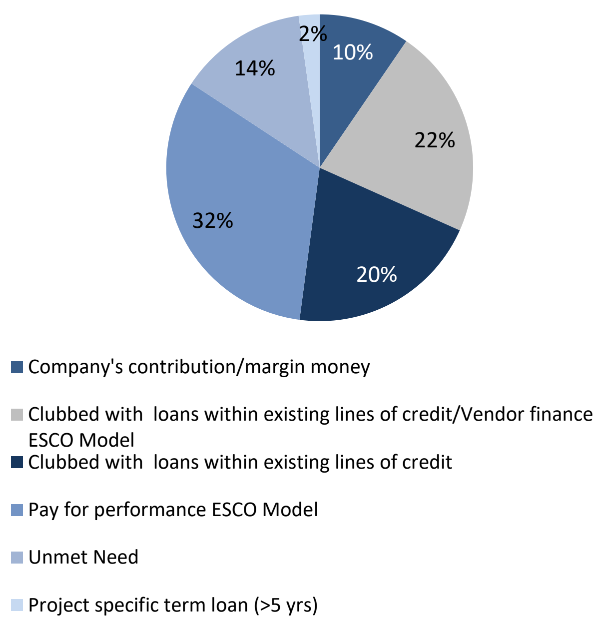
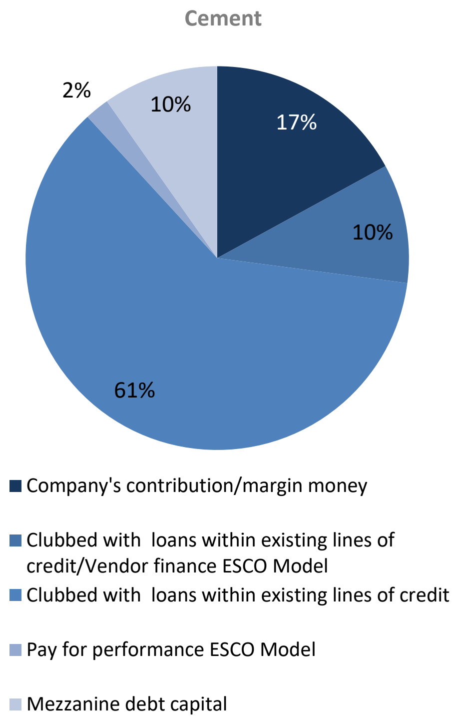
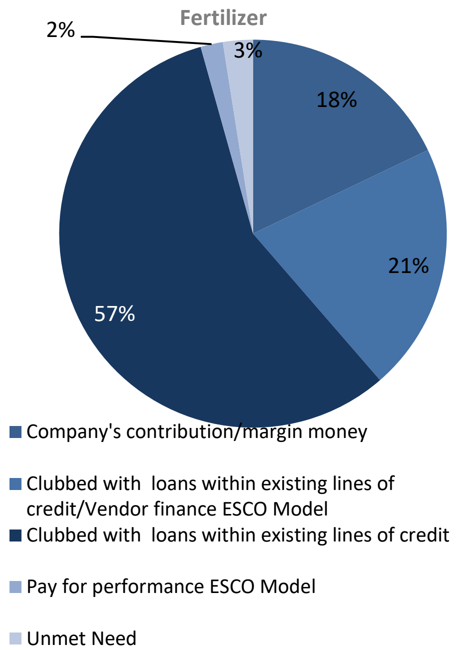


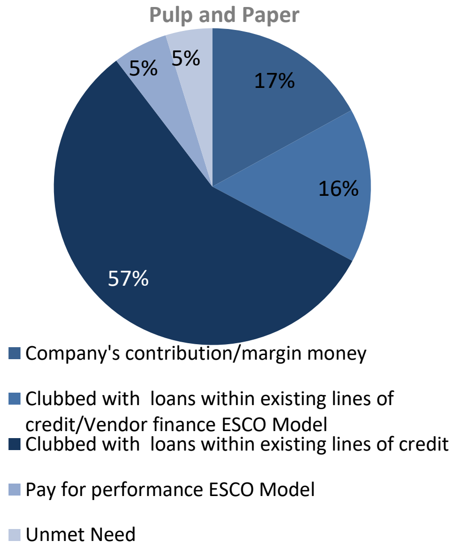
Figure 16: Small DCs- Potential financing routes for EE interventions



However, with smaller DCs (whose fixed assets are less than Rs 500 crores) the story is different. There is a larger potential of pay for performance ESCO model with 32% (Rs.900 crore) of the total EE investment potential potentially getting funded through that route and another 22% (Rs 610 crores) getting split between vendor finance ESCO model and getting clubbed with existing loans. An additional 20% (Rs. 560 crores) can be financed primarily by getting clubbed with existing loans. About 2% of the total potential, which amounts to Rs. 60 crore, can be potentially met through project specific term loan while about Rs. 375 crore (14%) can remain as unmet needs for financing energy efficiency within small DCs.

Sector wise break up of potential financing routes

Overall sector-wise break-up of financing routes	Description
	**Likely financing pattern:** In the Cement sector, out of the total investment potential of Rs. 15,000 crores, 60% or approx. Rs. 9000 crores can most likely get clubbed with loans within existing lines of credit while another 10% or Rs 1500 crores can be split between vendor finance ESCO model and getting clubbed with existing loans. Another 10% of the total financing requirement can be met through mezzanine debt capital. **Types of projects to be financed:** This split is observed primarily because of the fact that all the process interventions considered within cement sector (such as vertical roller mills for finish Grinding, using EAF slag –CemStar, high efficiency Clinker Cooler retrofit and increased use of fly ash— **have short term payback of less than 3 years and account for a relatively low percentage of overall capex for the cement plant (<3%), thus most likely to be funded by internal accruals/existing lines of credit only.** For cross-cutting technologies (CCT) - VFD and WHR, the small DCs can potentially opt for financing through Equipment Vendors/ESCOs if those alternative sources of capital are available.
	**Likely financing pattern:** Out of the total estimated investment potential of Rs 3900 crores in the fertilizer sector, 57% or about Rs. 2200 crore can be met through loans within existing credit lines, while 2% (Rs. 72 crores) can be funded by pay for performance ESCO model and 3% (Rs. 97 crore) can be classified as unmet need. Around 21% or Rs 807 crores can be split between vendor finance ESCO model and getting clubbed with existing loans. **Types of projects to be financed:** This break-up can be attributed to the fact that within Fertiliser sector, the considered process-interventions (installation of Vapour Absorption system, two stage regeneration in CO_2 Removal System, retrofitting Steam Turbines for higher efficiency, using an Adiabatic Pre-reformer) account for a small percentage of overall capex but have a medium term payback (3-5 years) which makes loans within existing lines of credit as most optimal route for large DCs but an unmet need for small DCs. No interventions qualify for project specific term loan.

<table>
<tr><th>Overall sector-wise break-up of financing routes</th><th>Description</th></tr>
<tr><td>


</td><td>

Likely financing pattern:

In the Pulp & Paper sector, out of the total investment potential of ~Rs. 2300 crore, 57% or approx. Rs.1300 crore can most likely be funded through loans within existing lines of credit, 6% (Rs.130 crore) be most likely funded through pay for performance ESCO model while 5% (Rs. 115 crore) would be unmet need.

Types of projects to be financed:

This sector has a significant scope of CCTs including VFDs, Super-Efficient Boilers and WHR which are likely to get financed through vendor financing route or ESCO model, especially for small DCs. The intervention related to firing of Black Liquor at High Concentration is unlikely to have the optimal financing route available for small DCs and thus this intervention would have an unmet need. No interventions qualify for project specific term loan or mezzanine debt capital in this sector.

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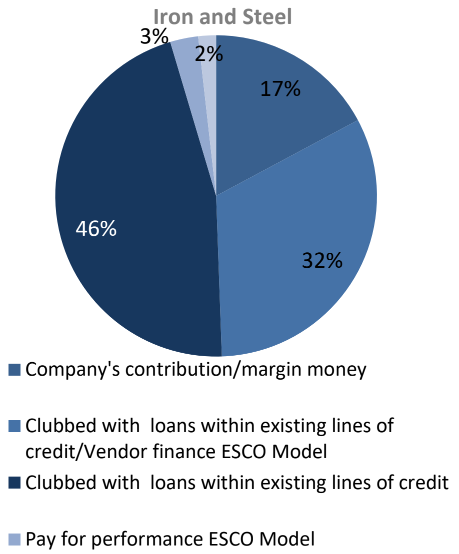
<tr><td>


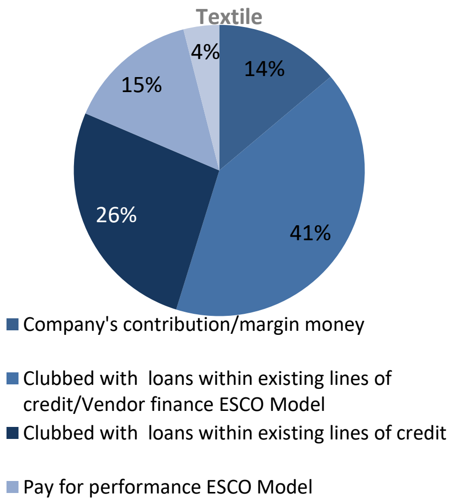
</td><td>

Likely financing pattern:

The Iron & Steel sector witnesses a likely potential of about Rs. 5500 crore out of which 46% or about Rs. 2500 crore can be clubbed with loans within existing lines of credit and almost 32% can be split between vendor finance ESCO model and existing loans. Approximately 3% (Rs. 150 crore) can be financed through pay for performance ESCO model route and 2% (Rs.100 crore) can be classified as unmet needs.

Types of projects to be financed:

This split can be attributed to the fact that a larger proportion of total financing, either for CCTs- VFD, WHR or for process interventions (Waste Heat recovery from sinter bed, Coke Dry Quenching, Top Pressure Recovery Turbine, Programmed heating in coke oven) — can be optimally funded through existing lines of credit, especially for large DCs. The smaller DCs can adopt the pay for performance ESCO model for CCTs like VFD and WHR.

</td></tr>
<tr><td>


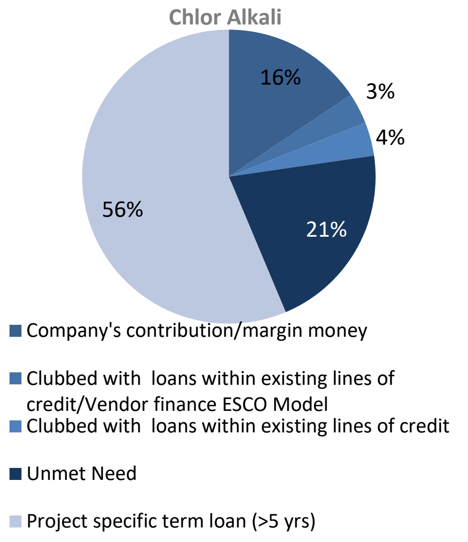
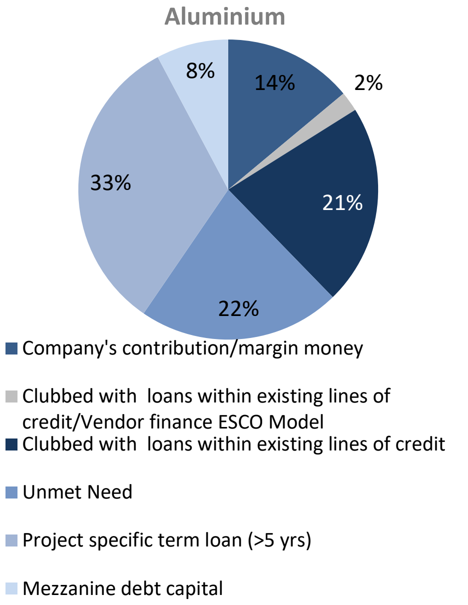
</td><td>

Likely financing pattern:

In the Textile sector, out of the total Rs. 1600 crore investment potential, 27% or approx. Rs.430 crore can most likely be funded by getting clubbed with loans within existing credit lines while 40% will be split between this route and vendor finance ESCO model. 15% or approx. Rs 235 crores can be funded by pay for performance ESCO model.
With a significant mix of small DCs in the sector, pay for performance ESCO model for CCTs such as VFD, WHR and super-efficient boilers is likely to form a relatively large chunk of the financing mix.

Replacement of lighter spindle in place of conventional spindle in a Ring Frame, a process improvement intervention (accounting for 4% or Rs. 64 crore) which doesn’t involve significant capex investment is likely to have an unmet financing need primarily due to the long term payback of investment.

</td></tr>
</table>

Overall sector-wise break-up of financing routes	Description
	**Likely financing pattern:** For Chlor-Alkali sector, the maximum proportion of financing for energy efficiency projects/process interventions can be most likely met by project specific term loan (with greater than 5 years tenure), with a share of 60% or approximately about Rs. 300 crore of the total Rs. 530 crore investment potential with this sector. 4% or Rs. 19 crore can be most likely funded primarily by getting clubbed with loans within existing lines of credit primarily for Ion Exchange Membrane Cell Process -Adaptive Control system. Investment potential of Rs. 110 crore out of the total is the unmet financing need of this sector which is primarily linked to the small DCs wanting to undertake Anode and Membrane replacement along with Zero gap conversion of Electrolyser. Financing for CCTs i.e. VFD can be most likely done through loans within existing lines of credit route or vendor finance route depending on the size of the DC.
	**Likely financing pattern:** For Aluminium sector, 33% or Rs. 1400 crore approximately out of the total investment potential of about Rs. 4300 crore for the sector, would require project specific term loan (with greater than 5 year tenure). This is primarily linked to investment in Inert anode (PBANOD) in Hall Heroult Process which requires significant capex and has a long term payback. DCs with strong balance sheets would be able to fund this intervention through the above mentioned route but this will be an unmet need (22%, i.e. Rs. 960 crore) for those with stretched balance sheets. 21% of the total investment potential in the sector or about Rs. 950 crores can be most likely met by getting clubbed with loans within existing lines of credit route as these are for short term payback with high return. Some portion of the CCTs (approximately 8% or Rs. 340 crore) can be most optimally funded through mezzanine debt capital. There is limited scope for vendor/ESCO finance route in this sector.

Cross Cutting Technologies have maximum potential for Vendor/ESCO finance

Energy efficiency interventions such as Variable Frequency Drive (VFD), Waste Heat Recovery (WHR) and super efficient boilers which find applicabilty across multiple industry sectors, are likely to be most amenable for financing offered by the equipment supplier (vendor finance) or the project being implented by ESCOs.

Vendor finance/ESCO model presents a Rs 6000 crore potential in the 7 PAT sectors (except thermal power plant sector)

Several reasons can be attributed to this likely trend for CCTs, including:

- Energy saving are easily measurable/quantifiable
- Do not have a significant upfront capex (as a % of overall capex for the firm)
- Payback are usually short term

Rs 1400 crore (~USD 200m) is the unmet need with existing financing instruments

Out of the total Rs. 34,000 crore investment potential, approximately, 4% or Rs. 1400 crore, is currently the unmet financing need for Energy Efficiency projects/process interventions.

The maximum share of unmet financing need is for Inert anode (PBANOD) in Hall Heroult Process within Aluminium sector which is a process change characterized by significant capex and long term payback, thus rendering it difficult for DCs with stretched balance sheet to raise new project finance for it.

Table 6: List of interventions whose financing needs are unmet

Sector	Intervention	Financing need (Rs crores)	Share of total unmet need
Chlor-Alkali	Anode and Membrane replacement along with Zero gap conversion of Electrolyser	110	8%
Pulp & Paper	Firing of Black Liquor at High Concentration	114	8%
Textile	Replacement of lighter spindle in place of conventional spindle in a Ring Frame	64	4%
Fertilizer	Installation of Vapour Absorption System	6	0.5%
Fertilizer	Two Stage Regeneration in CO2 Removal System	30	2%
Fertilizer	Using an Adiabatic Pre-reformer	62	4%
Iron & Steel	Waste Heat recovery from sinter bed	10	1%
Iron & Steel	Coke Dry Quenching	88	6%
Aluminum	Inert anode (PBANOD) in Hall Heroult Process	954	66%

Key levers to realize the investment potential: policy push and standardization in EE project definitions

1. Policy push to prioritize Energy Efficiency - Across the board, conversations with DCs, ESCOs, lenders and solution vendors revealed that a greater push at a policy level was required to spur action and prioritize Energy Efficiency investing. These can include:
    a. More stringent Energy Efficiency norms and a policy that levels playing field for all companies in a sector
    b. Providing tax incentives for industry (companies) to adopt ESCO route like it was done in China, which may encourage the industry in this direction.
2. Developing standardized M&V protocol, project document templates, reporting templates, underwriting procedures and capacity building of lenders to understand energy efficiency financing and more so ability to make use of existing lines/guarantee facilities

3. Standardized pay for performance contracts to be created coupled with the use of advanced measurement systems to quantify savings generated against dynamic baselines which would reduce the risk perception associated with some of the energy efficiency interventions and allow greater participation by ESCOs in the industrial energy efficiency market. This would also include:
    a. Exploring pooling of standardized projects by ESCO in order to make the ticket size of debt more meaningful and diversify the risk for a bank (provided the ESCO's balance sheet allows it)

Conclusively, one can simply put that perhaps a 'market-maker' is missing- to bring industry, financial institutions and ESCOs together. Collaboration is very important to take a combined responsibility for the bigger issue—i.e. enhancing the energy efficiency among industries in an ethical, responsible and definitely in a sustainable way.

Methodology

Sustainability Outlook and AEEE have developed a decision matrix which will help assess the most optimal route for financing energy efficiency interventions. This matrix considers the following variables:

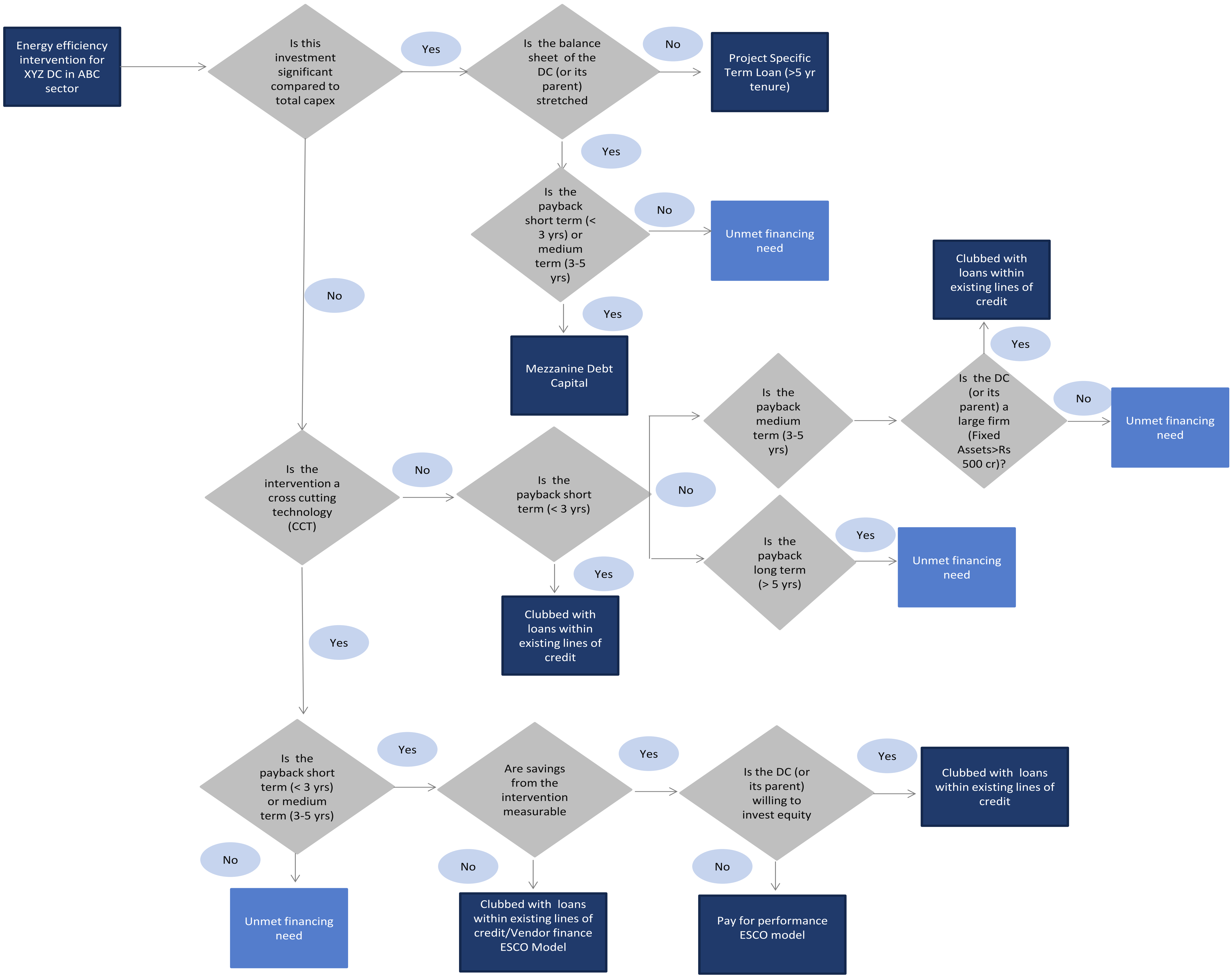
2. Type of Energy Efficiency intervention
    a. What is the significance of capital expenditure required for the intervention (as a percentage of total capex required by the firm to set up manufacturing capacity in that sector)? (any intervention which requires more than 3% of the firm's capex has been considered as significant)
    b. What is the simple payback of intervention? (less than 3 years is classified as short term, between 3 and 5 years as medium term and greater than 5 years as long term payback)
    c. Whether the intervention is a cross cutting technology or linked to process improvement?
3. Type of firm undertaking the intervention
    a. Size of fixed assets (as a measure to gauge the size of the firm)
    b. Strength of the balance sheet

Keeping the above metrics in mind, the optimal financing routes for the energy efficiency interventions considered for the purpose of this analysis (refer PAT Pulse May issue for a detailed list of energy efficiency interventions), are primarily the following:

6. Project Specific Term Loan (>5 yr tenure)
7. Clubbed with loans within existing lines of credit
8. Vendor finance ESCO model
9. Pay for Performance ESCO model
10. Mezzanine Debt Capital

The analysis has also found that suitable financing routes do not exist for certain EE interventions and thus their financing needs remain unmet.

Energy Efficiency Financing Decision Matrix






ASSET OPTIMIZATION TO DRIVE THE NEXT WAVE OF ENERGY EFFICIENCY IN INDIA

Highlights:

- Achieving performance efficiency and cost savings through optimization of Overall Equipment Effectiveness will define the next wave of Industrial Energy Efficiency.
- The market penetration of IoT based smart manufacturing solutions will increase from current levels of ~5% to 30% by 2020 and this would be driven by reduction in the cost of technologies.
- Increasing awareness about the potential and business case of IoT based smart manufacturing solutions will be crucial to reach the next stage of Industrial energy efficiency.
- Skill building would be required for enhancing the ease of using IoT based smart manufacturing solutions at the factory operators' end and for developing good quality data scientists at the solution providers' end.

The Fourth Industrial Revolution will be spurred by Smart Manufacturing

We live in an age of data and smart technologies. The pace of change experienced by the globe with the evolution of Internet has been exponential. Industries have seen complete disruptions owing to this. For example, conventional retail stores are increasingly facing the heat owing to development of e-commerce websites. Banking today is just a matter of a few finger clicks when compared to the completely manual process that was followed as recently as 15 years ago. Hiring a taxi and getting the most optimum deal for it is easier than it has ever been before. The manufacturing sector will not be cocooned from such changes.

As per the Make in India Initiative, the country is expected to rank amongst the world's top three growth economies and amongst the top three manufacturing destinations by 2020[13]. Unlike other sectors like IT, the manufacturing sector has not witnessed any major disruptions in the past few decades[14]. However, the pressures are building up on industries to optimize their efficiency with resources becoming increasingly scarce, competition getting fiercer and technology advancing at a an incredible pace. In order to fulfill the Make in India vision and to stay competitive, the Indian manufacturing sector would necessarily need to keep up with advancements in this sector globally.

It is predicted that 20.8 billion things could be connected by 2020. WEF predicts a Fourth Industrial Revolution with the advent of cyber-physical systems which facilitate global networks for businesses incorporating machinery, warehousing systems and production facilities, while continuously focusing on resource productivity and efficiency.

The number of sensors shipped increased more than five times from 4.2 billion in 2012 to 23.6 billion in 2014[15]. The World Economic Forum has identified that we are on the cusp of a fourth industrial revolution. The First Industrial

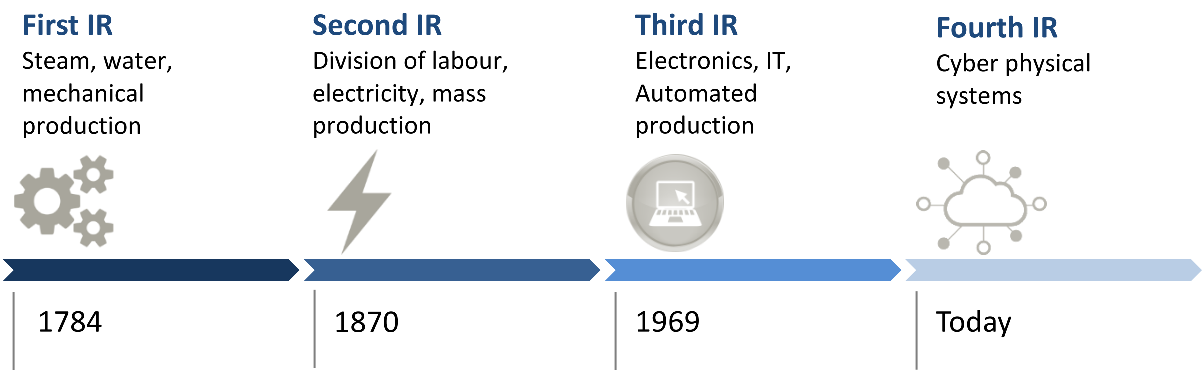
[13] http://www.makeinindia.com/article/-/v/direct-foreign-investment-towards-india-s-growth , Accessed on May 20, 2016

[14] Knud Lasse Leuth, Will the industrial internet disrupt the smart factory of the future?, March 2015 http://iot-analytics.com/industrial-internet-disrupt-smart-factory/ , Accessed on May 15, 2016

[15] Elfrink, Wim. "The Internet of Things: Capturing the Accelerated Opportunity". October 2014. http://blogs.cisco.com/ioe/the-internet-of-things-capturing-the-accelerated-opportunity

Revolution used water and steam power to mechanize production. The Second used electric power to create mass production. The Third used electronics and information technology to automate production. Now a Fourth Industrial Revolution is inevitable with the advent of cyber-physical systems which facilitate global networks for businesses incorporating machinery, warehousing systems and production facilities, while continuously focusing on resource productivity and efficiency[16].

Figure 17: Industrial Revolution (IR) Timeline



Source: WEF

Such systems which will be enabled by Information and Communication Technology (ICT) will additionally improve the visibility on energy consumption and GHG emissions for industries. A radical transformation within manufacturing is possible only if it is known where inefficiency occurs throughout the processes and workflows within a factory. Such ICT technologies can provide the data, which can be used to change behaviours, processes, capabilities and systems[17].

So it is clear that the fourth industrial revolution will be spurred by Smart Manufacturing.

Smart Manufacturing: The Next Big Leap Influencing Energy Efficiency

The American Council for Energy-Efficient Economy defines Smart Manufacturing (SM) as "*the use of information and communications technology to integrate all aspects of manufacturing, from the device level to the supply chain level, for the purpose of achieving superior control and productivity*"[18]. SM involves utilization of data communicated by equipment and processes within the product value chain and its conversion in to real insights in order to make real time decisions and achieve the traditional goals of manufacturing of improvement of productivity. O'Donnovan has elucidated SM by calling it data-driven manufacturing where data is acquired through ICT infrastructure such as sensors in the factory and synthesized to drive informed decision making[19]. Such a digital **transformation can be enabled through technologies such as Internet of Things (IoT), machine learning, SMAC (Social, Mobility, Analytics, Cloud) technologies.** For the purpose of this brief we have focussed on SM solutions with regards to their applications within the factory's fence in order to have a better definition of boundary conditions.

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[16] Industries 4.0 working group, Securing the future of German manufacturing industry: Recommendations for implementing the strategic initiative INDUSTRIE 4.0, April 2014, Pg. 5
[17] The Climate Group, SMART 2020: Enabling the low carbon economy in the information age, 2008, Pg. 14
[18] Ethan A. Rogers, The Energy Savings of Smart Manufacturing, July 2014, http://aceee.org/research-report/ie1403 Accessed on May 15, 2016
[19] O'Donovan et al. , An industrial big data pipeline for data-driven analytics maintenance applications in large-scale smart manufacturing facilities , Journal of Big Data 2015 2:25

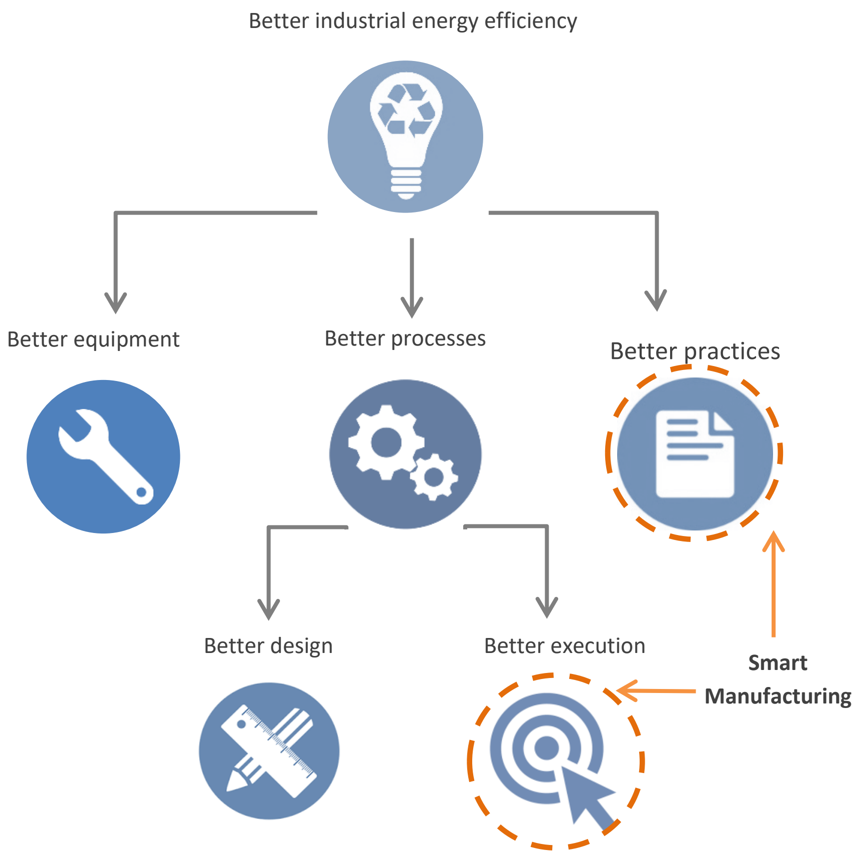
Figure 18: Simplified Features of IoT Based Smart Manufacturing Solutions

The Economist Intelligence Unit in their report "Intelligent Manufacturing: Targeting better energy efficiency" has identified that energy efficiency can be brought about by better equipment, better processes and better practices. Better processes could be achieved by better process design and better process execution. Smart manufacturing solutions enable better process execution and better practices by utilizing intelligent insights that are born out of the data collected from multiple areas within the factory.

Smart manufacturing solutions enable better process execution and better practices by utilizing intelligent insights that are born out of the data collected from multiple areas within the factory

Good quality data is at the heart of SM and acquisition of the same could be achieved through the internet, wireless technology or conventional wire connected technology.

Figure 19: Influence of Smart Manufacturing on Manufacturing Efficiency



SM solutions don't look to change the core process of the factory but just look at how the existing capacity and process can be utilized better. Simply put, they look to reduce the non-value added time from the production process and improve the flow within the factory using data as a driver.

Internet of Things as a Key Enabler for Smart Manufacturing

In India the Union government's department of electronics and information technology, in its draft policy, aims to create a $15 billion IoT industry in India by 2020[20]. Cisco's 2013 report on "Internet of Everything" states that, the highest percentage (27%) of value in future IoT revenue will be in manufacturing[21]. **With such impetus on IoT, the market conditions would be favourable for solution providers to tap in to the Indian market for smart manufacturing.**

It is important to appreciate that the Internet of Things as a technology is pretty unique as it entails the collaboration of four distinct industries. There are:

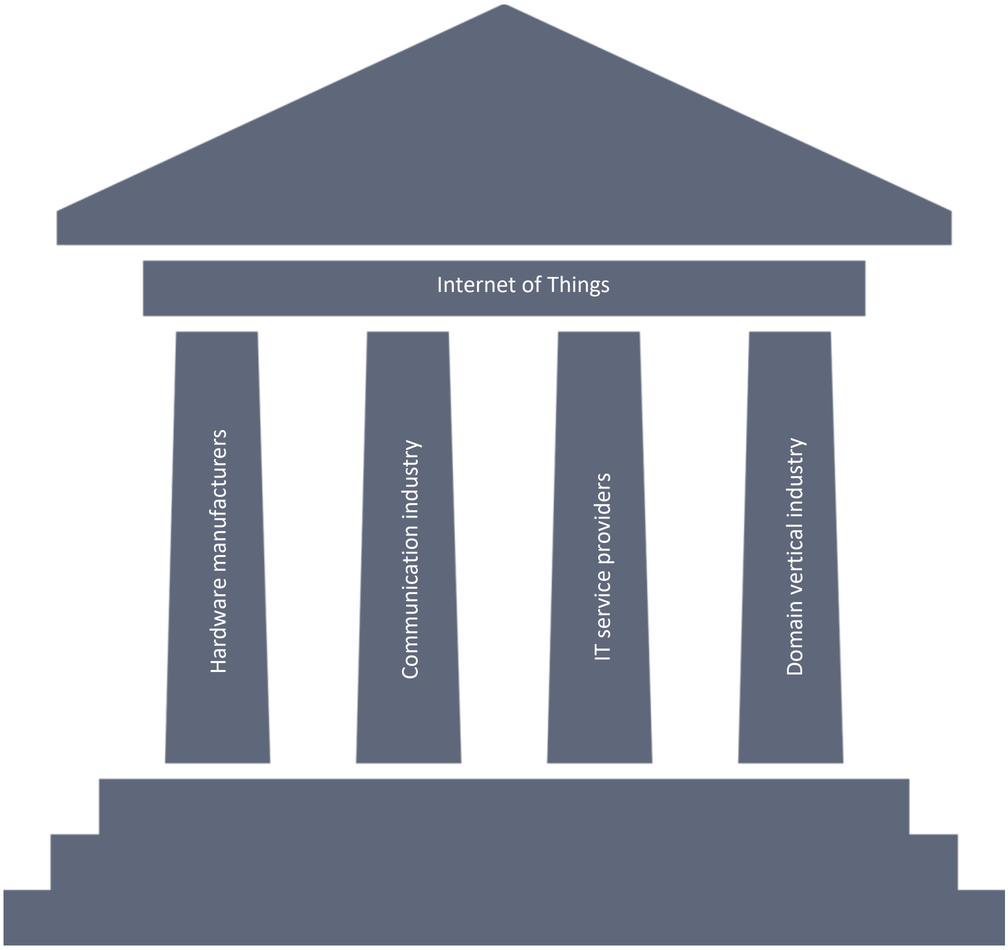
1. **Sensor manufacturers**: They are responsible for accurately capturing information
2. **Communications industry**: They are responsible for transfer of information
3. **Information Technology Service providers**: They are responsible for analysing and presenting the information
4. **Specific domain of application**: Expertise in specific manufacturing sectors, for example, any of the PAT sectors

[20] http://deity.gov.in/content/internet-things , Accessed on May 18, 2016

[21] Cisco, The Internet of Everything: Global Private Sector Economic Analysis, 2013, Pg. 9

These four solution/service providers need to work together to come up with a common robust solution.

Figure 20: The Four Pillars of the IoT Industry



For the purpose of this brief we have focused primarily on **IoT based Smart Manufacturing solutions**.

Good Quality Data Drives the Development of Intelligence

Good quality data is what the entire concept of IoT and Smart Manufacturing rest on. The process flow of IoT starts off with assets within a factory communicating data regarding their condition, time of operation, production, etc. by means of sensors that would be installed on the asset. Furthermore, some of this data may also be provided manually through some digital device. All of this raw data is captured and transferred through network connectivity elements such as a mobile communication network, Bluetooth, Wi-Fi, Ethernet, etc. This data is stored in a database platform. The analytics platform takes the data from the storage and picks out only the useful bit and synthesizes it in to information which can be communicated to the end user. Finally, this information is provided to the user through applications which present the data through reports, dashboards, etc. on the graphical user interface of mobile devices, computers, etc.

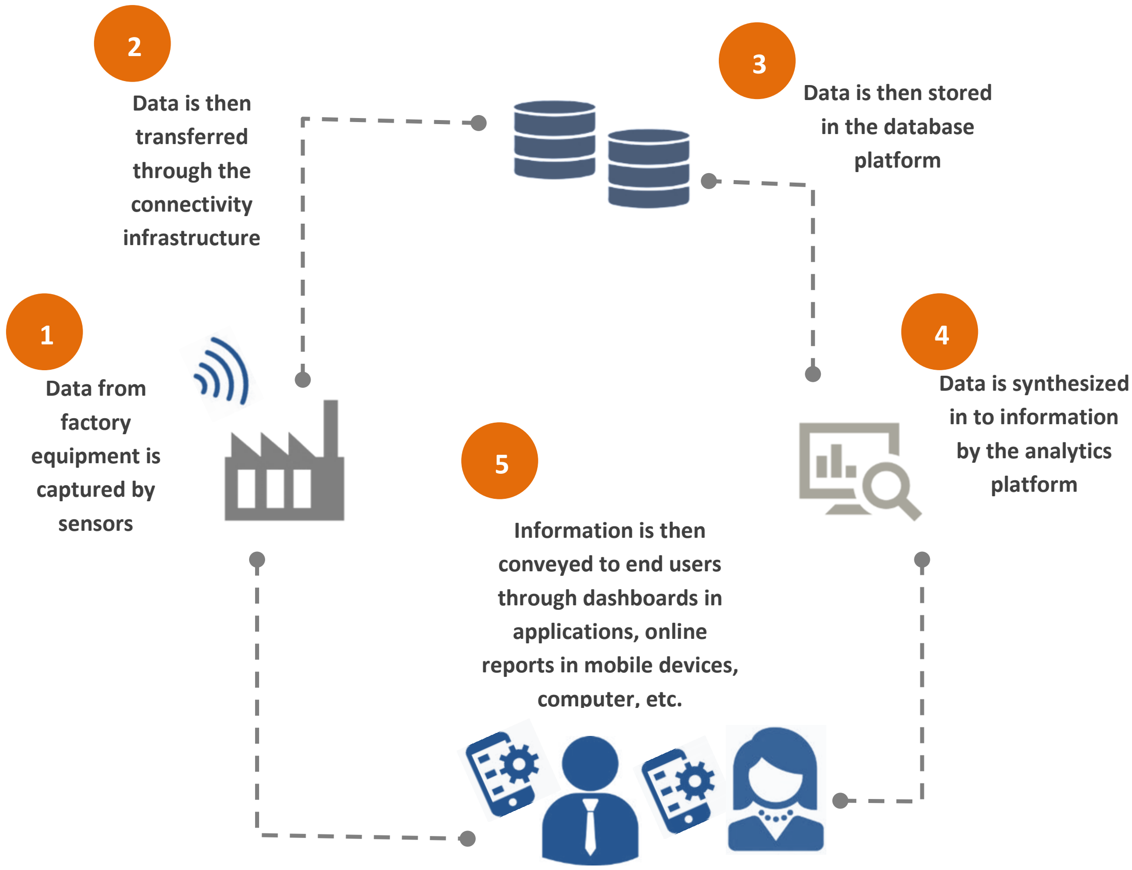
Figure 21: Data capability and maturity model[22]

	DATA AVAILABILITY	DATA ACCESSIBILITY	DATA CORRELATION	ANALYTICS	REPORTING	MANAGE RESULTS
TARGET	Data from all available devices is recorded and historized Data definitions are common and shared across	Real time and historical data is easily accessed Data is accurate	Data is correlated in common reports Talent can develop and test new correlations easily	Analytics are easily performed Talent is optimally utilized	Reporting is real time & historical trends easily available Sharing various reports within & across plants	Key talent work on factors pertinent to the bottom line Performance levels are sustainable
CURRENT	Data is available but not collected Data definitions are unique to each plant Historical data is lost	Data is manually collected or manipulated	Data correlation requires manual intervention Correlation across plant siloes is not existent	Analytics not performed Analytics requires manual intervention Capabilities of talent not utilized	Reporting is limited, manual and point-in-time Sharing across plants is not easy	Key talent spends time measuring instead of managing results Attrition creates gaps in knowledge

Going further, this information could be used for machine learning and building predictive capabilities within the solution that is being provided. Also, this information could be transmitted to an automation actuator that performs an action based on the inputs provided to it.

[22] Source: Alcoa, The SMART Manufacturing Business Case, 2012, Pg. 8

Figure 22: The Layers of Data in IoT Based Smart Manufacturing Solutions



Asset Optimization: An Emerging Area for Smart Manufacturing Solutions

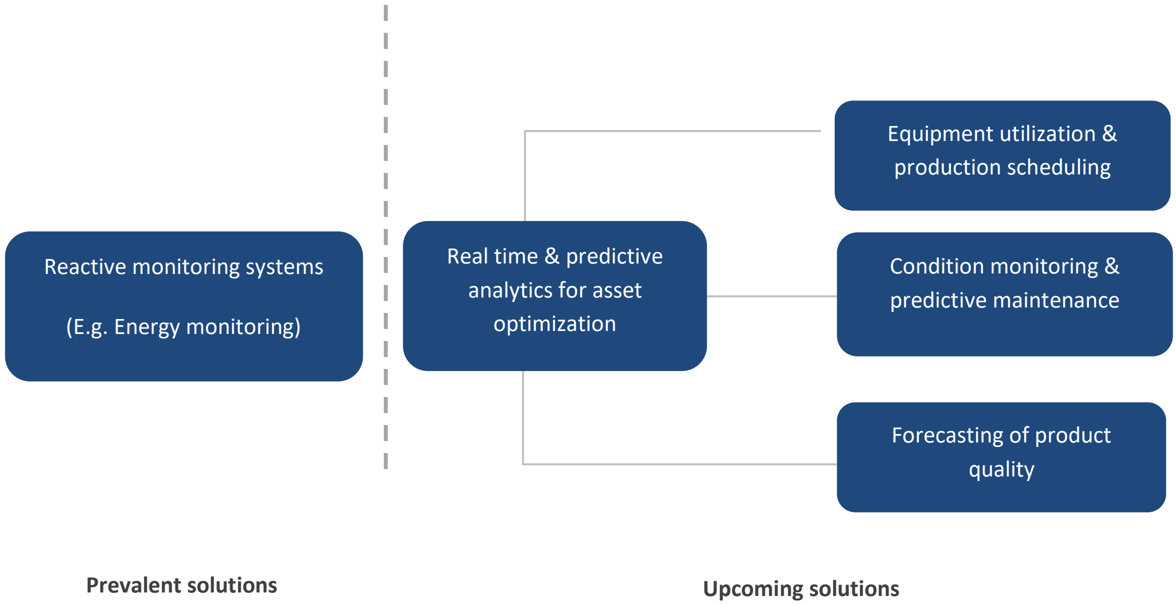
What sets IoT based smart technologies apart is that they provide insight and actionable information to the end users as also possess capabilities for predicting future conditions

Currently there are a host of solutions in the market that capture raw data and present it in a usable form to the users. However, what sets IoT based smart technologies apart is that they provide insight and actionable information to the end users as also possess capabilities for predicting future conditions based on historical data that is assimilated over a period of time. Essentially these technologies digitize the data that may be readily available at factories and build on it to build intelligence in to the factory's value chain.

The IoT based SM solutions for applications within the factory's fence which are coming up in the market today focus predominantly on asset optimization. Gaining visibility on entire operations of a plant on a single screen as also monitoring parameters such as machine idling time and predictive maintenance are areas which are upcoming. Most of these are currently carried out in a manual fashion through logbooks, etc. Asset optimization directly influences energy efficiency. Instances of machine failures and under-utilization of machines also have a significant impact on energy efficiency. GE announced that it has realized more than USD 1 billion in incremental revenues in 2014 by helping customers improve asset performance and business operation through industrial internet capabilities and services[23].

[23] GE press release. GE to Open Up Predix Industrial Internet Platform to All Users, October 9, 2014. http://www.genewsroom.com/pressreleases/ ge-open-predix-industrial-internet-platform-all-users-278755 Accessed on May 20, 2016

Figure 23: Areas of Application for Smart Technologies



Potential of Improving Overall Equipment Effectiveness (OEE)

For any manufacturing unit, the overall equipment effectiveness (OEE) is an important indicator of asset utilization. OEE can be described as the ratio of actual running hours of a given equipment or process when compared to the planned running hours of the same. The deviation from planned operation is owing to non-value added tasks such as waiting, machine changeovers, stoppages, and maintenance and quality issues in the product. Global averages for OEE are at 60-70% with the world class units hovering at around 85%[24]. In India the average OEEs range from as low as 35%[25] in aluminium manufacturing to as high as 89%[26] for machine component manufacturing. The monetary impact of improvement in these numbers could be significant.

Equipment Utilization and Scheduling Can Instantly Impact Energy Efficiency

Given the number of machines that exist in a typical process oriented factory along with complex material flows, it is cumbersome to get a real time picture on how effectively is each machine running when compared to its output and with minimal idling time. Furthermore, synthesizing all of this real time information to come up with optimal production schedules and other systematic action points can be a further challenge. Also sometimes plants maybe located at remote locations and may necessitate remote monitoring. Also, with regards to energy efficiency, a machine that runs without producing any output clearly is a waste of the energy that is used to run it. IoT driven SM solutions can help for each of these points.

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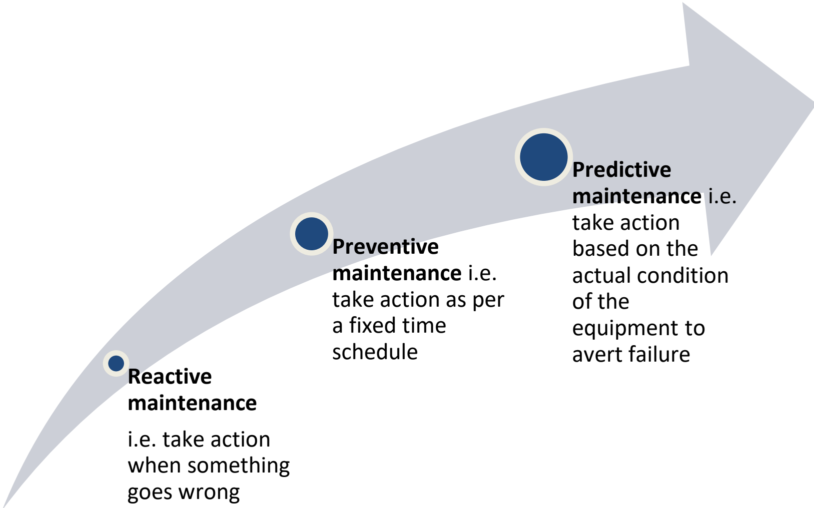
[24] Knud Lasse Leuth, Will the industrial internet disrupt the smart factory of the future?, March 2015 http://iot-analytics.com/industrial-internet-disrupt-smart-factory/ , Accessed on May 15, 2016

[25] Palanisamy, Vino, Implementing Overall Equipment Effectiveness in a Process Industry, Indian Journal of Science and Technology, Vol 6 (6S) | June 2013

[26] Bangar, Sahu, Batham, Improving Overall Equipment Effectiveness by Implementing Total Productive Maintenance in Auto Industry", International Journal of Emerging Technology and Advanced Engineering, Volume 3, Issue 6, June 2013

Predictive Maintenance has Direct Economic Benefits

Today machine maintenance is carried out by technicians either when problems arise (reactive maintenance) or at fixed intervals as a routine (preventive maintenance). When problems arise and the machine has to be serviced, it leads to production delays and a high service effort which consequently leads to high cost. Industrial maintenance accounts for over 30% of a factory's annual operating costs and between 60-75% of a machines lifecycle cost[27]. One can gain better visibility on equipment's conditions by monitoring certain parameters such as temperature, current, voltage, revolutions per minute, etc. For instance, looking at the vibrations of rotary equipment can give good visibility about its condition. Today's IoT based SM solutions not only look to report on such parameters in real time but also look to carry out mathematical analysis on this bulk data, compare the results with critical values and predict when a components could fail so that action can be initiated much before the failure actually occurs (predictive maintenance). Also, with such forecasts in hand the technician can liaise with the production department and can plan for materials and scheduling of the maintenance in a much better fashion thereby ensuring that unexpected downtimes and consequent losses are reduced.



- IoT enabled solutions can also help in conducting systematic root cause analysis and assimilate the learning for making the factory operation even more intelligent.
- Predictive maintenance primarily enables factory owners to optimize the maintenance and support costs.
- Also it enables the factories to optimize their insurance premium where they could actually go for usage based insurance since there is much more clarity on the state of the equipment.

Timely maintenance of equipment does not only save costs associated with over-maintenance or under-maintenance but also prolongs the life of the machinery by preventing the number of times the machine enters in to a state of disrepair

The amount of energy used by a machine can increase if its conditions are not optimal i.e. if it operates in an inefficient state. When a component within a machine nears failure, wastage of the energy consumed is manifested in the form of abnormal vibrations, sound and heat. Also, machines that do not run at expected specifications can adversely impact the quality of the output. Thus, costs associate with rejections and rework can be optimized. Timely maintenance of equipment does not only save costs associated with over-maintenance or under-maintenance but also prolongs the life of the machinery by preventing the number of times the machine enters in to a state of disrepair[28].

Forecasting of Product Quality Enables Timely Correction of Flaw

Monitoring of quality of output on a real time basis with predictions for rejections is another area where IoT based SM solutions could help. The sooner a defect is detected the easier it is to correct it as well as prevent its occurrence in the

[27] O'Donovan et al. , An industrial big data pipeline for data-driven analytics maintenance applications in large-scale smart manufacturing facilities , Journal of Big Data 2015 2:25

[28] O'Donovan et al. , An industrial big data pipeline for data-driven analytics maintenance applications in large-scale smart manufacturing facilities , Journal of Big Data 2015 2:25

rest of the production. Rejections and the rework not only impact time of delivery but are also a cause of use of excess resources. The solutions that are coming up in these areas today provide end users with information which they can act upon. A further evolution of this would be automation based on this information so that the equipment in question can take actions on itself.

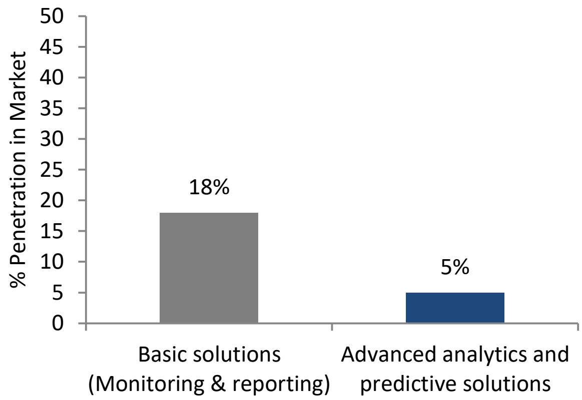
Smart Manufacturing Solutions Currently have Low Penetration in India

All factories today are under pressure to cut production costs and improve their bottom-line. Moreover, businesses today want to gain better visibility across their organization in a centralized manner so that they can make informed decisions. Given the monetary benefits linked with smart technologies, it makes financial sense to implement such solutions. Also, most of the IoT based solutions that are gaining traction in the market are not sector specific and can be configured to any industry depending on the clients' requirements and the specific use case for which they are being deployed.

Most of the IoT based solutions that are gaining traction in the market are not sector specific and can be configured to any industry depending on the requirements and the specific use case

Yet, currently the manufacturing sector (including PAT sectors) is still trying to transition to digital data capture from the predominantly manual processes. **The basic solutions that provide monitoring and reporting options have a market penetration of about 15-20%.** Unless data is captured accurately and is reliable, analytics solutions cannot be applied to it. **However, as per market estimates, solutions which provide advanced analytics and predictive modeling currently have a penetration of less than 5% across the industries.**

Figure 24: Estimated Current Market Penetration of Data Based Manufacturing Solutions



Trailblazing Sectors: Iron & Steel and Power Generation

Any manufacturing unit that has sizable consumption of resources such as energy, water, chemicals etc. and has already implemented low-hanging interventions for efficiency and are likely to look at smart manufacturing solutions going forward. Manufacturing units that have some form of digitized data collection system (such as e.g. SCADA system) are likely to find it easier to adopt IoT based SM solutions.

IoT based solutions that are available today are easier to install in factories that already capture information in a digitized form.

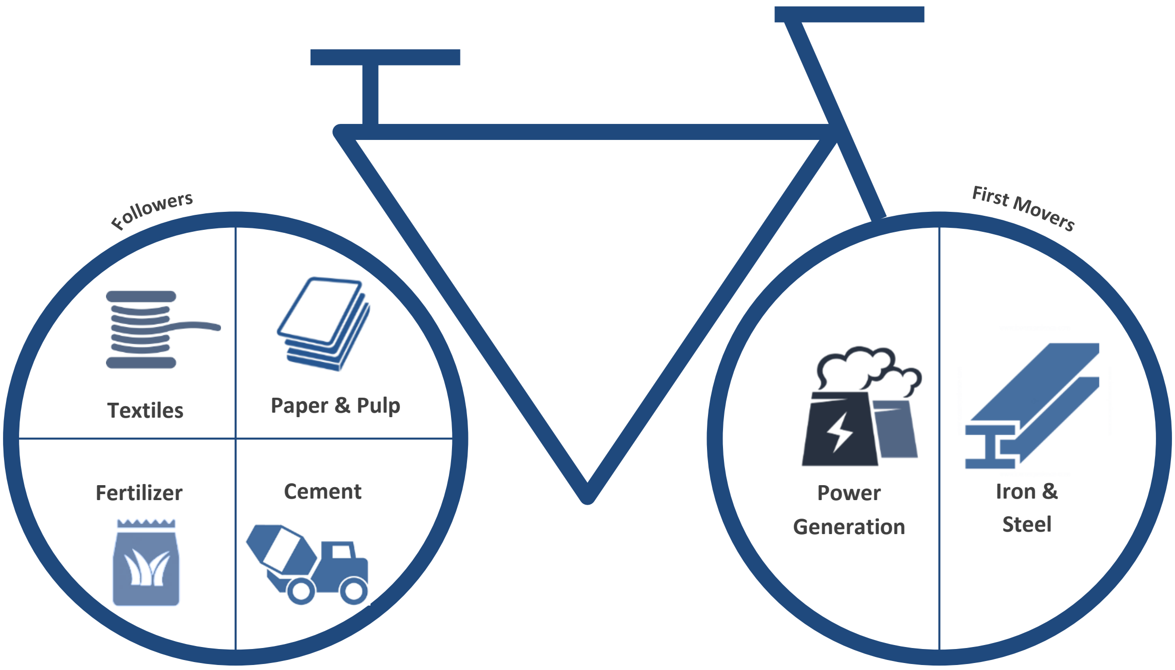
Within PAT sectors iron and steel and power generation have seen the highest amount of interest so far in IoT based smart manufacturing solutions. In both these sectors, the optimized operation of equipment based on their design specification and monitoring of various sections within the plant are the areas where IoT based SM solutions find applications. In the iron & steel sector, the heavy machinery involved in movement of material (such as cranes, etc.) provides an opportunity for IoT based solutions.

The pace of uptake is highest in sectors which collect a fair bit of data owing to regulations, etc. (E.g. Online monitoring of wastewater quality & quantity). However there is a massive opportunity to leverage this data for better decision making.

Other PAT sectors such as textiles, paper & pulp, fertilizers and cement have also shown some interest and depending on their size have initiated pilots for implementation of IoT based SM solutions.

Among non-PAT sectors, the automotive sector which has usually been at the helm of digitization has seen good uptake of IoT based solutions. Retail, transportation, oil & gas, pharmaceuticals, utilities, health care, consumer goods, smart cities, renewable energy generation and consumer electronics have also seen increasing interest. The rest of the sectors yet need to be handheld and nudged slightly.

Figure 25: PAT Sectors that are using IoT Based SM Solutions



However, it is important to note that certain specific utilities that exist across sectors such as boilers and steam distribution systems, compressed air systems and water and waste water treatment which exist across industries may see quicker uptake of IoT based SM solutions and present many case studies for other interested factories to use.

Utilities that exist across sectors such as boilers & steam distribution systems, compressed air systems and water and waste water treatment may see quicker uptake

The uptake of IoT based SM solutions is much stronger in the west which itself will drive Indian factories to follow suit. Further, India's good cellular infrastructure already is paving the way for ensuring reliability of data transfer. The large sized players with larger budgets for improvements are the first movers for IoT based solutions and they are implementing pilots to gauge the effectiveness of such solutions. So it is safe to say that an evolution is taking place at the supply side with solution providers improving their offerings as well as at the demand side with factories venturing out of their comfort zones. Also, sectors maybe at a threat of being completely disrupted by new technologies which may necessitate the shift towards new solutions.

Business Case for Smart Manufacturing: Potentially 10-15% Energy Savings, 12-15% of Productivity Improvements

The definition of a precise business case for IoT based SM solutions is difficult because they could find multiple applications within a factory and the net outcome could be difficult to quantify (e.g. quantifying the impact on life of the machinery). Also, the same solution may not be applicable to one factory as it is to another. However, through our interactions with multiple solution providers and the results observed so far are very encouraging:

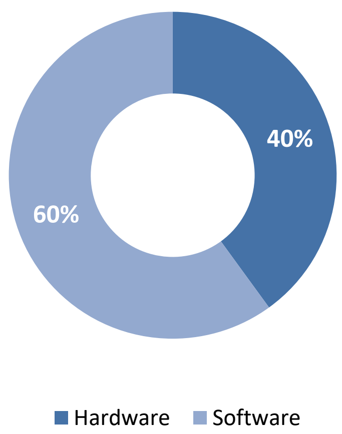
- **Savings in energy to the tune of at least 10-15% could be anticipated**
- **Energy monitoring and management solutions alone have the potential to reduce energy costs by 4-5%.**
- **Operations and maintenance expenditure could be reduced by 2-5%.**
- **Productivity improvements are also estimated to be at a minimum of 12-15% by just basic monitoring of equipment and streamlining of production schedule.**

Figure 26: Estimated Benefits from IoT Based SM Solutions

60% of solution costs linked to software component

Almost all solution providers offer end-to-end solutions that include the hardware as well as software costs. However, most solution providers are specialists in the software component. Hence, they form strong collaborations with various hardware suppliers in order to offer a complete solution to the end customer. The price of the solutions can usually be bifurcated in to one pertaining to the initial installation and one pertaining to an ongoing subscription of sorts. The price point is dependent on the use case in the factory, the complexity of assets, the number of sensors required, the sensitivity of sensors, etc. **Currently the solutions that are available in the market could be priced in a range of INR 50,000 for a small scale machine to INR 3,50,00,000 for a large complex factory.**

Figure 27: Estimated Cost Break-up of IoT Based SM Solutions



Payback Ranges from 12 – 60 months; Depending on Complexity of Solution and Extent of Coverage

The payback periods for smart manufacturing solutions are difficult to predict in a simplistic manner. For example, one manufacturer was able to recover the investment made within a span of 9 months by just analyzing the downtime of the equipment. Advanced analytics was not even used in this case. However, on an average such investments could be recovered in anywhere between **12-60 months**. This could also be attributed to the fact that for predictive modelling to start taking shape, a fair bit of historical data is a pre-requisite. Investing in such technologies is like investing in to ones past and present in order to secure the future of the factory.

Illustrative Use Cases of IoT Based Smart Manufacturing Solutions

Use Case	Illustrative Scenario	Impact Category	Impact	Solution Provider
Textile plant enhances revenue through monitoring solution	In a leading textile plant with capacity of 1.4lakhmeter/day, a machine supplied by world's best bleaching machine manufacturer was able to produce 94% of Grade A textile. There is approximately INR 100/meter difference between Grade A & Grade B textiles. On implementation of the Intelligent Plant Framework (IPF) solution (a platform which provides real time visibility of the complete plant) it was observed that there were frequent stoppages of small duration that were never coming to notice for the mid and senior management.	Improved production scheduling	By addressing this stoppage issue, the factory improved their quality levels with Grade A textile occupying 97.8% of the total production. This enabled the factory to generate additional revenue of INR 0.5 million/day or INR194 million/year).	**Covacsis Technologies Pvt. Ltd.** (Source: http://www.covacsis.com/case-study/impact-of-stoppage-analysis.pdf)
Captive power plant optimizes fan speeds through real time analytics solution	A 235MW captive power plant in a steel plant had fans that are used for air cooling the condensers. Though these fans utilized the latest VFD technology, their speeds were not being controlled effectively. A real time analytics engine was implemented which was capable of recommending the optimal speed of the fan array to the operators. The analytics engine was also able to understand the vibrational pattern of the fan motor and provide early warnings of potential failure. The solution was non-invasive and required no additional capital expenditure.	Increased Equipment utilization Condition monitoring & Predictive maintenance	The solution resulted in direct 18% reduction of energy consumption of the cooling process in the form of 3000 units saved per day. It also reduced the unplanned shutdown of the plant and reduced the risk in operations. The optimal speed recommended by the analytics engine was much lower than the maximum speed which reduced the wear and tear of the motors and prolonged their life.	**Altiux** (Source: http://www.altiux.com/_include/whitepaper/Altiux%20Case%20Study%20-%20Using%20Analytics%20to%20Reduce%20the%20Energy%20Consumption.pdf)
Condition monitoring at iron &	The key parameters for optimization of a plant are throughput, product quality, machine availability and		The reduction of incidences of production shutdowns linked to	**IBM**

Use Case	Illustrative Scenario	Impact Category	Impact	Solution Provider
steel manufacturer	efficiency. Small flaws, such as temperature imbalances in a furnace or the wrong tension setting on a steel roller, can lead to defective products, customer dissatisfaction and costly delays. An iron and steel manufacturer was keen to spot emerging equipment and product-quality problems early. The solution provider created a solution that analyzed large volumes of production control data to seek patterns in equipment operations, product quality, failure patterns etc.	Condition Monitoring Improvement of product quality	equipment failure and product defects enabled savings of at least USD 2 million for every 0.1% improvement in production efficiency. The solution has also helped in embedding of process knowledge into equipment and process optimization algorithms.	(Source: http://www-05.ibm.com/sk/optimalizacia-investicneho-procesu/pdf/E_U_Presentation_Sanna.pdf)
Productivity improvement at a plastic component manufacturing unit	A plastic component manufacturing factory was facing challenges such as unavailability of real time data for decision making, cumbersome manual production log entries and delayed response to machine failures resulting in longer downtimes. They implemented an IoT based SM solution which enabled them to have real time real time dashboards to view production information for all machines, real time monitoring of production, rejections and downtimes, overall equipment effectiveness, detailed analytical reports & graphs, real time alarms and escalation for quicker response times to problems on the Shopfloor and historical trend Analysis.	Improved production scheduling Increased equipment utilization	With the help of monitoring solution the factory personnel eliminated inefficiencies on the shop floor and received alarms in real time for critical production issues. This resulted in productivity improvement by 30% and digitization of manual entries has saved over three person years at the factory.	**Entrib Technologies Pvt. Ltd.** (Source: Shopworx case study “Manufacturer of Plastic Parts for Consumer Electronics; Improving Shop Floor productivity with ShopWorx’ Real Time Monitoring Solution”)

Use Case	Illustrative Scenario	Impact Category	Impact	Solution Provider
Enhancing product quality intelligently	One of the Largest adhesive manufacturer in the world wanted to increase the quality and yield of the factory lines by controlling 2 parameters - viscosity and softening points. The IoT signal intelligence platform set up by the solution provider was ingested with 3 years of sensor data regarding plant operations from temperature sensors, rpm sensors, torque sensors and pressure sensors which were strapped on to industrial mixers. The platform's ensemble models enabled filtering of useful signals from noise and specifically identified the contributors to quality. This process was eventually scaled to 33 plants, 1400 manufacturing lines and 16 event types and cumulatively 20 million sensor events were analysed.	Improvement of product quality	The manufacturer has realized more than USD 140 million of savings from preventing defective products across 3 years	**Flutura Business Solutions Private Limited** (Source: https://www.flutura.com/stories.php?transformation-story2)
Ensuring timely receipt of spare parts	One of the World's largest manufacturers of Shale field equipment and natural gas/diesel engines was heavily dependent on OEMs to minimize asset failures and downtime. There was a specific problem that they wanted to solve for: How to proactively auto generate spare part requests triggered by sensor events and thereby reduce inefficiencies? The solution provider's Prognostics/Diagnostics platform ingested signals from a variety of frontline industrial assets in real time like - Acidizing units, Fracking pumps, chemical additive units, blenders, large generators,. The specific signals analyzed include Pressure signals, Oil temperature signals,	Condition monitoring & Predictive maintenance	Knowing the forecast of spares helped the manufacturer to plan for its acquisition.	**Flutura Business Solutions Private Limited** (Source: https://www.flutura.com/stories.php?transformation-story2)

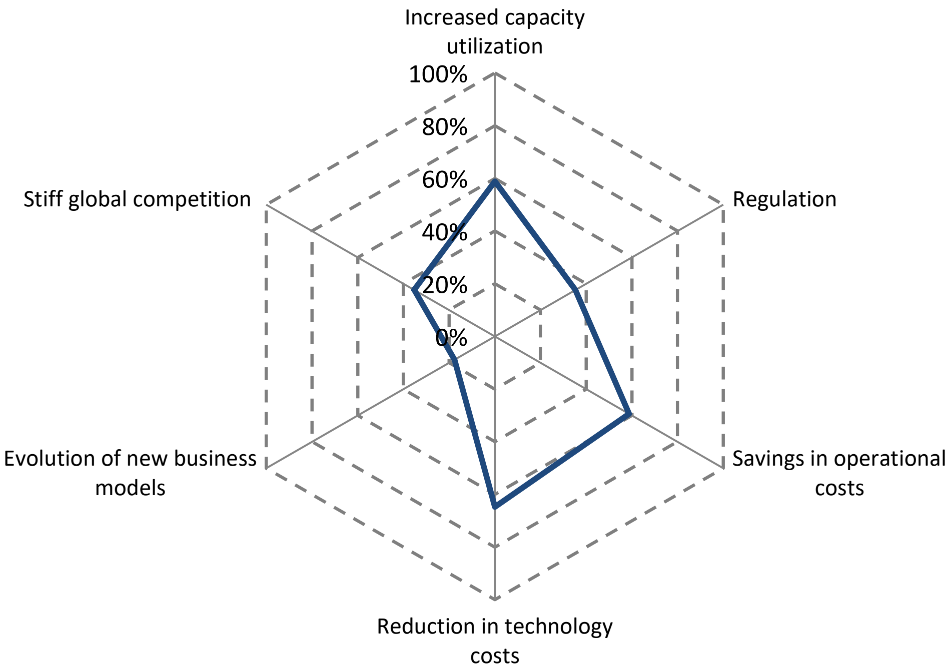
Use Case	Illustrative Scenario	Impact Category	Impact	Solution Provider
	horse power signals, rpm signals, discharge pressure signals to find Anomalies to Potential Fault Modes, predict Failures & Maintenance Requirement and Forecast Spares requirement.			
Predictive maintenance of compressed air systems	After the implementation of a IoT based predictive maintenance solution for a compressed air system, an operations analyst at a unit received an alert that a power cylinder did not reach normal operating temperature after a compressor was restarted. After further investigation, the analyst noticed that there was a 500 F difference between the exhaust temperate for cylinder 1 and the other cylinders. The history for the unit showed that cylinder 1 typically operated near the same temperature as the other cylinders and that the unit was currently operating at 76% of its rated brake horsepower load. This information prompted the analyst to contact the team at the station. Conditions on the pipeline demanded that the unit continue to run to meet a critical need for storage injections. After pipeline conditions improved, the gas control team approved taking the unit offline. The team at the station found a bad fuel valve, and promptly replaced it.	Condition monitoring & Predictive maintenance	The use of IoT based SM solutions prevented recurrences of the incidents that almost caused compressor failures at a given station. Intangible benefits also included increased customer confidence, improved reliability and asset availability.	**Columbia pipeline group and Rovisys** (Source: https://www.plantengineering.com/single-article/predictive-maintenance-for-gas-pipeline-compressors/6b0eb1d148595946a81ee5fe8b21aae9.html)

Reducing Technology Costs Coupled with the Need to Optimize Performance Efficiency and Reduce Operational Costs Likely to be the Key Drivers for IoT Based SM Solutions

IoT and analytics based solutions provide the end users with the ability to find a needle in a haystack. Manufacturers are increasingly realizing the importance of data for gaining better visibility in to their operations and are analyzing it for streamlining their processes. Such insight and information also enables manufacturers to make good decisions and respond better to market needs.

Through multiple conversations with experts[29] from the industry we gathered that the likely reduction in costs of technology components associated with IoT based SM solutions, would be the biggest driver for adoption of such technologies. Further, the need to fully utilize the current installed capacity of equipment and the persistent emphasis on reduction of operational costs would also compel industries to look at unconventional solutions.

Figure 28: Drivers for IoT Based SM Solutions in the Future



- **Reduction in technology costs**: The technology associated with IoT and analytics based solutions has evolved significantly in recent years. The technology associated with connectivity infrastructure is constantly improving. The solutions are getting smarter and increasingly able to sense only the intelligent data from the bulk of data that is collected and send it for storage. Hence, the cost of such technologies today is a fraction of what it used to be few years ago. The costs associated it will continue to go down in the future. This includes the cost of sensors, cost of controllers, cost of storage, cost of communication infrastructure and cost of smart devices coupled with development of new open source platforms. Consequently solution providers will be able to provide even more attractive price points which will drive their uptake across industries.

> Manufacturing units that have some form of digitized data collection system (such as e.g. SCADA system) are likely to find it easier to adopt IoT based SM solutions

[29] Sustainability Outlook and AEEE interviewed around 20 solution providers related to smart manufacturing for the purpose of this brief

- **Better capacity utilization**: Today's industrial structure is driven by performance so the focus is likely to shift from capacity addition to better capacity utilization of existing assets while maintaining the objective of making better quality products. The idea would be to do more with less. In time, non-adoption of such technologies could actually threaten the very existence of businesses.

- **Reduction in operational costs**: The reduction in operations and maintenance cost as well resource usage costs are going to be an important driver for uptake of smart technologies. IoT based SM solutions can directly impact energy efficiency too. With time, the business case will be better defined and the willingness of manufacturers to invest in such technologies would improve.

- **Global competitiveness**: The world is becoming flat and markets are increasingly becoming competitive in a global sense with manufacturers in the United States of America, China and European nations constantly enhancing their practices. Thus there is an ever present need for manufacturers in India to perform better, maintain an edge and protect their market share. Digitization is going to become a key feature for manufacturers to stay competitive.

- **Policy/Regulation** that can be enforced properly could be another driver in the future. If stringent targets for asset utilization and energy efficiency are mandated by law, then it would compel even the small and medium scale manufacturers to dive deeper in to their operations and identify avenues for improvement.

Online monitoring of DCs

IoT based solutions could open up avenues for online monitoring of energy consumption of DCs. Also, the whole process of PAT validation and ESCerts issuance could potentially become human independent and verifiable.

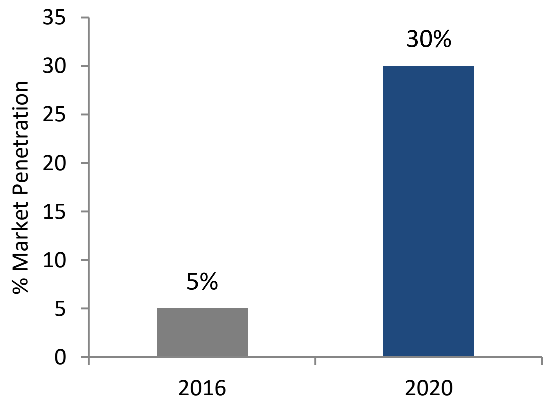
Starting at the periphery

IoT and analytics based solutions could be initiated at the peripheral components of a factory such as utilities. The approach should be to initially avoid the core process and look for opportunities in other resource hotspots.

- **New business models**: The market is getting more innovative and competitive with entirely new business models and products that are being enabled by IoT and analytics based solutions E.g. In the future, assets could be provided on rent to manufacturers by original equipment manufacturers. These new models would drive the uptake of IoT based solutions.

The market is responding to these solutions today due to which they are slowly but surely gaining traction**. By 2020 the market penetration is likely to increase by at least 30% on an average across various industries in India (Fig 13).** This penetration is going to be much larger in the US and Europe. It is likely that the bigger players will continue to lead the way for such solutions.

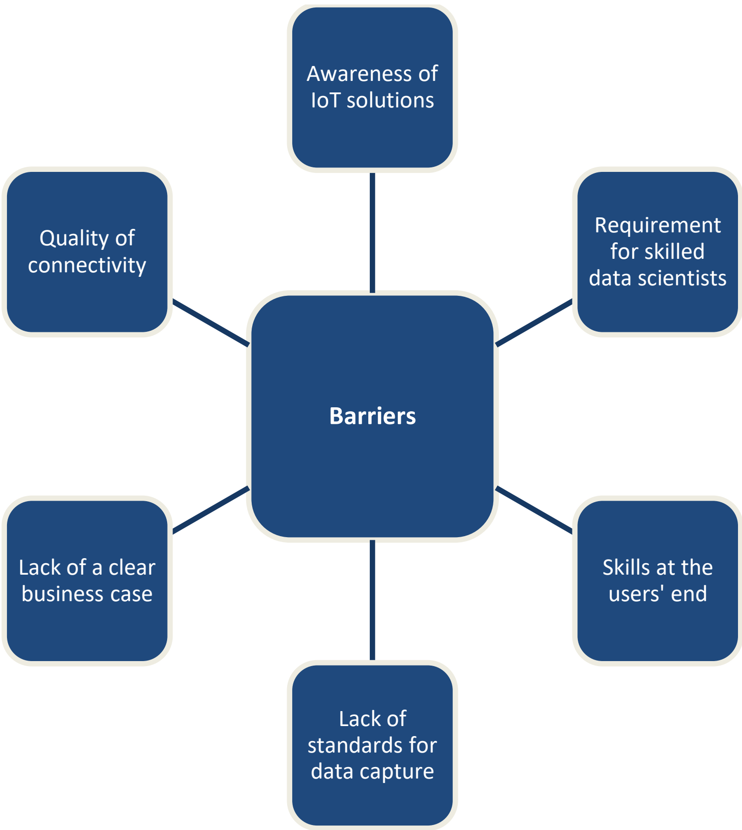
Figure 29: Current and expected penetration of IoT Based SM Solutions



Change Management and Definition of a Clear Business Case Could be the Biggest Challenges for Uptake of Smart Manufacturing Solutions

The biggest barrier that currently hampers the uptake of IoT based SM solutions is the lack of awareness about the solutions available in the market, their features and their likely benefits. Further, due to the nascence of the solution the clear cut quantification of benefits linked to it may not be very. Thus the construction of a business case becomes difficult.

Figure 30: Barriers for uptake of IoT Based SM Solutions

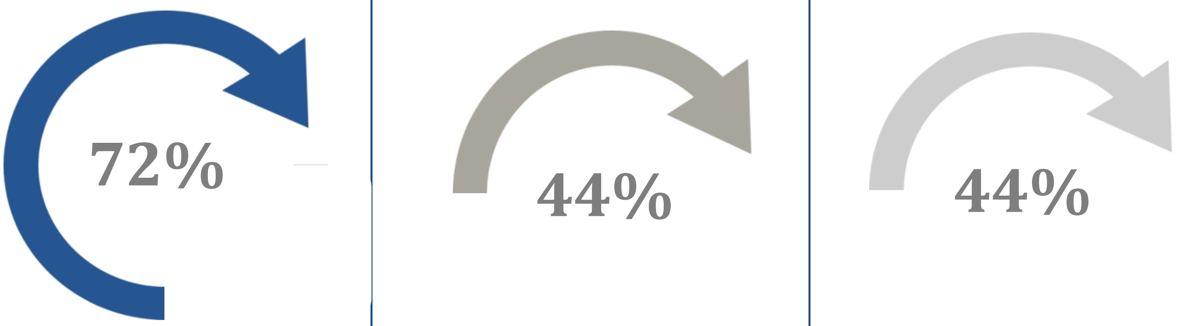


- **Awareness about capabilities of IoT based SM solutions**: Implementing IoT based SM solutions in manufacturing requires a complete change in the thought process of the people who run the show. This change need to happen at every level within the factory, right from the management to the floor supervisors. At the management level there needs to be willingness to work on a new technology as also be ready for slightly longer payback periods. Traditionally in India, paying for software is a bit of an alien concept which is something that needs to evolve. At the same time, on the shop-floor level the operators need to be brought on board and involved even in the pilot implementation phase, to make them see how IoT based SM solutions (if used well) would make their jobs easier and not more complicated. Also, it is far easier to incorporate new technologies in a new plant. However, in India there are lots of brownfield projects where technology change or upgrade is challenging and necessarily requires a massive component of change management for people. Today, positions within the management as well as the shop-floor are being filled in my younger people, who might naturally have a higher propensity to work on such solutions.

> **Implementing Pilot project to garner confidence**
>
> Today solution providers encourage their customers to go for small scale pilot projects, where by both parties involved can get a hang of the problem being addressed and can arrive at tangible results for the same.

- **Definition of clear business case / use case**: The success of IoT based SM solutions is also heavily reliant on a clear definition of the use case for which it is being deployed. The management hence needs to be aware of what exactly they want to monitor and how are they going to utilize the data and insights that would flow out the new solution. This is further compounded by the lack of clear quantification of savings and perceived high cost of implementation. Under these circumstances, stating the business case becomes challenging. Also current pricing of certain high end solutions is high. IoT as a technology would become more promising and persuasive when there are larger volumes of data to be handled. For lower volumes, the cost of the infrastructure (cloud and amount of devices to be managed) may not be attractive.

- **Skill gap at the operator level**: In India, most of the people on the factory shop floor are likely to not be technology savvy. It is essential for all such personnel to upgrade their skills so that they can make good use of the insights provided by IoT based SM solutions and tap into them to get the best possible outcome.



72% respondents felt that there is a lack of awareness about IoT based SM solutions

44% respondents agreed the lack of ready case studies and lack of definition of the business case / use cases hamper the uptake of IoT based SM solution

44% respondents believe that there is a skill gap at the users end with regards to the usage of IoT based SM solutions

- **Standardization of data capture** from machines and associated protocols is a concern especially for solution providers. As IoT based SM solutions will gain traction, the interoperability of various systems and devices may pose a challenge to realization of a larger scale IoT which could result in disparate islands of solutions[30].

- **Quality of communication**: Availability of consistently robust communication infrastructure is crucial to the success of implementation of IoT based solutions. For example, poor cellular and internet connectivity especially in remote places could hamper the monitoring of equipment within the factory. Also, if connectivity is intermittent the system needs to be designed such that data is transferred in a smart and efficient manner.

Data science: an upcoming field

Data science is a new and upcoming field which involves extraction of meaning and insight from bulk data.

- **Lack of data scientists**: For the projected growth in IoT, there would be a need of 200,000 personnel who are skilled in data science and can manage such complex solutions[31]. Data science is a new and upcoming field which

[30] Mindtree, Making sense of interoperability: Protocols and Standardization initiatives in IOT, http://www.cymbet.com/pdfs/Low_power_IoT_ComNet_2013_Mindtree.pdf, Accessed on May 19, 2016

[31] http://www.fractalanalytics.com/news/how-india-building-its-analytics-talent, Accessed on May 19, 2016

involves extraction of meaning and insight from bulk data. Data scientists would typically be required by solution providers to design their offerings. Owing to this field's recentness, there is a dearth of skilled data scientists in the market today. Good data scientists need to have a unique bunch of strong skills in areas as diverse as mathematics, statistics, business, technology and also a keen sense of grasping the nuances of any specific domain.

Busting the myths related to Smart Manufacturing solutions

- **Threat to data security**

The security of data is critical. Given its criticality, solution providers today provide ample protection to ensure a safe and secure platform for the user.

- **High Downtime for installation**

The installation of IoT based solutions in fact is non-invasive and can be deployed in days with minimal downtimes at the plant owing to evolution of advanced meters and sensors.

Key Trends that are Likely to Emerge

With a growing young work force as an asset, India would be poised to capitalize on the wave of industrial smart technologies. As smart technologies will gain traction in the market, some key trends are likely to shape their direction.

- With use cases becoming clearer and increasing traction in the market for such solutions, the number of solution providers will increase too. These are likely to not be sector specific. However, they would need to continue to tweak and tailor their solution for each factory and not just every sector. Solutions that can be easily interpreted and have a low resource footprint will have an edge over the rest.
- Manufacturers will continue to seek end to end solutions. Hence, the market which may be fragmented at present will get increasingly consolidated.
- Hardware costs in particular will reduce. The kinds of sensors and their sensitivity will improve and move towards more rugged designs.
- Owing to the nascence of the market today, solution providers mainly provide solutions that give insights on current operations and predict what could happen. Going forward, these insights will be fed back in to the equipment in order to enable machine learning and initiate self-correction by the machine. Thus, automation based on analytics would be a key area that would emerge over the next few years.
- There could be a need for reorganization of the skilled labour of today.

Way Forward

The way forward for IoT based SM solutions would necessarily need to commence with improvement of awareness about available solutions. This could be addressed by solution providers by **making more case studies and project references** available to manufacturers which could help them gain confidence. Further, if the solutions are implemented in units that belong to an industrial cluster, it would help in spreading the experience through word of mouth among various factories within the cluster.

Also, to make factories more ready for such solutions, the **skill sets of the operational staff** needs to be enhanced through classroom and shop floor trainings using aid such as manuals, videos, hands on sessions that give out step by step procedures in a simplistic manner. Training could be provided to factory personnel on following topics:

  - Basic computer and software skills
  - Data entry and its quality(if applicable) and its importance

- Mobile applications and their interpretation
- Basic appreciation for IoT / Digitally connected assets
- Basic appreciation for analyzing data signals from assets and how to act on them based on insights provided by the IoT solution
- Guidance on customizing reports
- Cross functional skills cutting across engineering, operations, analytics, data

Such capacity building on this front needs to happen on an ongoing basis to address the attrition within the factory.

Which kind of factories would want to go for SMART solutions?

- Factories that have the right attitude towards change and evolution and understand the value of data as a change enabler
- Factories that are incurring heavy losses in terms of equipment downtime, scheduling problems, quality issues
- Companies that have remote operations and assets
- Factories that may need more of real-time data and analysis
- Factories that are already recording good quality data in some form or shape (be it electronically or manually). For example, factories that are already using some enterprise-wide software, SCADA systems, etc.
- Factories that have more installations of latest machinery, which usually come with data capturing capabilities
- Companies that are setting up greenfield factories so that the change management involved with new processes can be more smooth

Another likely possibility is that in the future the **influence of IoT based SM solutions on energy efficiency would move beyond the fence** of the factories to the entire value chain of manufacturing. The future will see evolution of solutions that enable everything to be connected and executed in real time. As per the principles of modern lean manufacturing processes, if the flow of material is perfect, production should be able to run at the speed of customer demand as opposed to following the conventional method of creating projections. IoT based solutions could be leveraged to connect everything and make the entire supply chain lean and responsive by manufacturing only that which is purchased by the customer. This would impact energy efficiency positively by avoiding wastages that occur due to waiting, work in progress, inventory, over production and under production within the factory as well as on the logistics side. The technologies and practices of smart manufacturing will complete the evolution of manufacturing from a supply-side-focused mass production to demand-driven mass customization[32].

We live in an increasingly connected world where technology is providing us with the opportunity to overcome human errors and to also utilize the capabilities of the human brain for more value added jobs. It is for us to approach such technologies in smart manner armed with the right use cases and tap in to them to extract maximum benefits from them. IoT and analytics based solutions today maybe an abstract statement for manufacturing plants, like the smartphone was until a few years ago. But it will become a necessity about 5-6 years from now and will be converted from a good-to-have item to something that would be absolutely essential in all sectors. The top management at the DCs' side will need to commit to their engagement in the process of piloting and implementation of IoT based SM solutions. Cross functional communication and data flow would be need to be facilitated by cross functional teams for reaping maximum benefits from such solutions. There are a fair bit of challenges and expectations that solution providers would need to overcome. Serious thought would also be required for re-skilling at many different levels. The main idea is that it is not factories and manufacturing that needs to be smart; it is also people that need to get smart.

[32]American Council for an Energy-Efficient Economy, The Energy Savings Potential of Smart Manufacturing, 2014, Pg. 11

INNOVATION LENS

Some of the latest technologies and innovations in the area of energy efficiency that have demonstrated their reliability successfully are listed below

Deep Eutectic Solvents cluster

Applicable sector:

This technology has one of the best applications in the Pulp and Paper industry and is also applicable for chemical industry. Apart from providing DES-based papermaking and sheet forming, Deep Eutectic Solvents (DES) can be used to eliminate water from papermaking entirely, prepare the stock and eventually, remove contaminants. It is expected that in future, DES could be used for recycled fibre processing and dissolving ink residues in paper which is recovered.

ISPT
Source: ISPT

Key Benefits and likely impact:

- Produces high quality cellulose, sulphur-free/unchanged lignin and hemicellulose.
- Revenue from the sales of chemicals through DES has the capability to cover most of the costs of cellulose production and it's estimated that a value increase of Rs.14, 780.43 to 22,170.64 (200-300 euros) per tonne of wood can successfully occur.
- Highly energy efficient as their processes does not require high temperatures.
- Bio degradable and Exerts low vapor pressure
- Mixable with H2O and non-toxic
- Exists as non-volatile and possesses low flammability
- Provides energy reduction by 40%
- Provides CO2 reduction by 20%
- The true savings lie outside the mill boundaries:
- If lignin is able to replace aromatics in the chemical industry, DES can provide up to -90% overall energy and CO2 savings

Description: Deep Eutectic Solvents (DES) are renewable, nature-based, biodegradable, cost-effective, low-volatile and energy efficient, as their processes do not require high temperatures. The best aspect of this technology is that they fully replace traditional pulping processes. Produced by plants, DESs open the opportunity for producing pulp at low temperatures and at atmospheric pressure itself. Any type of biomass could be dissolved into lignin, cellulose and hemicellulose along with minimal energy, emissions and residues using DESs. This new omnivorous pulp mill concept is expected to further allow tailor-made fibers to be produced, using a broader variety of raw materials and with significantly lesser use of energy, along with use of fewer chemicals. This would easily bring down the investment costs also to be less than half from that of a traditional chemical pulp mill. Cost-effective pulp production units, as much as 50 kilo-tonne per annum can be effective using DESs, meeting the growing demand for more localized production units, which ideally should close to resources. Hence in this way, DES-based installations can successfully cater to local and regional markets, reducing transportation, emissions and costs at the same time.

Source: http://www.unfoldthefuture.eu/uploads/report_final_for_emailing_latestv08.pdf,
http://www.ispt.eu/roadmap/deep-eutectic-solvents-cluster/,
http://www.cepi.org/system/files/public/documents/events/EuropeanPaperWeek2015/Heiner%20Grussenmeyer%20-%20Provides%20public%20kick-off%2019-11-15.pdf

DyeCoo's water-free fabric dyeing technology

Applicable sector:

The technology uses supercritical carbon dioxide instead of water for dyeing (fabric) textiles. Firms like- Nike and have used this waterless technology by DyeCoo, naming the process as "ColorDry".

Source: Dyecoo.com

Key Benefits and likely impact:

- Minimum to no water consumption, least use of chemicals,
- Requires no drying
- Two times or double efficiency in terms of time.
- CO_2 used is reclaimed from existing industrial processes, by recycling 95% of it in a setting of closed loop system.
- By eliminating the need to use water, along with addition of efficient colour absorption and short batch cycles – this technology proves to be energy efficient.

Description: In this new machine launched by Dutch company DyeCoo Textile Systems BV, the usage of water as a solvent in fabric wet processing is replaced by supercritical carbon dioxide. As per DyeCoo, "Supercritical CO2 has liquid-like densities, which is advantageous for dissolving hydrophobic dyes, and gas-like low viscosities and diffusion properties, which can lead to shorter dyeing times compared to water. Compared to water dyeing, the extraction of spinning oils, the dyeing and the removal of excess dye can all be carried out in one plant in the carbon dioxide dyeing process which involves only changing the temperature and pressure conditions; drying is not required because at the end of the process CO2 is released in the gaseous state. The CO2 can be recycled easily, up to 90% after precipitation of the extracted matter in a separator"

Source: http://www.dyecoo.com/pdfs/colourist.pdf, http://www.dyecoo.com/co2-dyeing/

Clearflo Technologies' Water softener plant

Applicable sector:

The technology is best applicable, both for residential and commercial purposes and among the industries, it pertains to all such sectors which have extensive use of hard water, like- within textile Sector, chemical factories.

Source: **ClearFlo Technologies**

Key Benefits and likely impact:

- Enables great reduction in operational costs pertaining to water softening
- Less priced, hence feasible for all large/small DCs
- Low power consumption
- Reduction of scales and clogging from pipes and vessels
- Automatic facilities to start the recharging cycle and so easy to operate.
- Increases the efficiency of appliances and the plumbing systems along with enhancing their service life too.
- Reduction of scales and clogging from pipes and vessels
- Automatic facilities to start the recharging cycle and so easy to operate.
- Increases the efficiency of appliances and the plumbing systems, along with enhancing their service life.
- Can operate as automatic, semi-automatic or manual.

Description: Designed as highly efficient plant, for converting any type of hard water into soft water removing the calcium, magnesium, sodium and iron from water, this water softener plant is offered by Clearflo

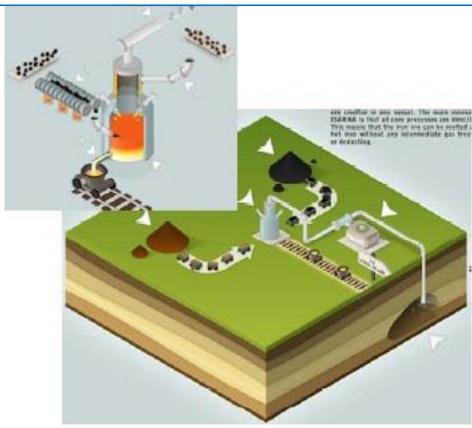
Technologies which offers other related equipment too for industrial applications, pertaining to energy consumption and hence ensure energy efficient practices. It is well-acknowledged that the hardness of water assumes prime importance in many applications, e.g. the preparation of drinking water, or the water in breweries and sodas, but also for cooling water and boiler feed water. Conceptually, water softeners are specific ion exchangers that are designed to remove ions, which are positively charged. They essentially remove calcium (Ca2+) and magnesium (Mg2+) ions, where these two ions are often referred to as 'hardness minerals'. Sometimes, softeners are even applied to remove iron and when used for that purpose, the softening devices are able to remove up to five milligrams per litre of dissolved iron.

Source: http://clearflo.in/water-softener-chennai.html, http://clearflo.in/water-softeners-for-%20hard-water.html

Ulcos' Top Gas Recycling Blast Furnace

Applicable sector:

This technology finds its application in the Iron and Steel industry. It has developed as an effective alternative to improve the performance of blast furnace.



Source: **Ulcos**

Key Benefits and likely impact:

- Requires effectively lower amount of coke
- Feasibility of a 26% coke saving/ton Hot Metal from the current BF coke consumption
- Feasibility of a 15% reduction of CO2/t-High Rupturing Capacity is expected without CCS (Carbon Capture and Storage) and up to 50% CO2 Reduction is expectedly possible with CCS.

Description: This technology, the Top Gas Recycling Blast Furnace conceptually relies on separation of the off gases so that the useful components can be easily recycled back into the furnace and eventually be used as a reducing agent. This would not only reduce the amount of coke needed in the furnace, but also through injecting Oxygen(O2) into the furnace instead of preheated air, it removes unwanted Nitrogen(N2) from the gas, facilitating Carbon dioxide (CO2) Capture and Storage (CCS).

Source: http://www.ulcos.org/en/research/blast_furnace.php, http://ietd.iipnetwork.org/content/top-gas-recycling-blast-furnace-0

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

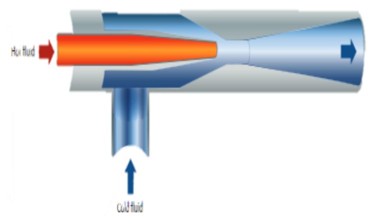
Source: MHI-Global

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

Nordic Power Converters
Powering a brighter future™

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

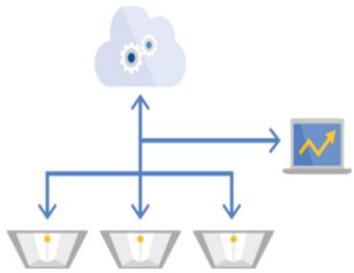
Source: http://monforts.com/

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/

Online Automated Cleaning of Condenser & Tube Heat Exchanger Tubes

Applicable sector:

- Small Power Plants (up to 60 MW)
- Process heat exchangers in industries
- Chemical & Petrochemical industries

ECOGREEN Systems LLP

Likely impact:
This innovation helps save 20% of the energy utilized in water cooled HVAC systems and 3% improvement in the power output. This also results in a reduction in the O&M costs. Investment: Rs. 23 lakhs, Energy savings: Rs. 10 lakhs, Payback: 5~6 months

www.ecogreensys.com

Description: The ECOMax-HE, innovation relates to the online cleaning of condenser/ shell & tube heat exchanger tubes; it uses the principle of periodic injection and collection of cleaning sponge balls at a predefined interval. It replaces the conventional method of offline acidic chemical descaling of the condenser tubes. The innovation helps to keep the condenser tubes clean always without any chemical usage and improves the heat transfer resulting into improved efficiency. The USP of this cost effective innovation is that it manages multiple condensers on one system easily.

Waste Heat Recovery Products for Industrial and Commercial Applications

Applicable sector: The products are applicable to most industry segments which have a concurrent requirement of utilities (air compressors/chillers) and hot water. Applicable to hotels, hospitals, dairies, food and beverages, textiles, automotive among others.

Likely impact: Promethean Energy is a heat recovery system designer and manufacturer. While the company sells directly to certain high value customers, their primary audience is channels like ESCO's or OEMs. For channel sales, Promethean would be making capital sales, along with an annual AMC contract.

www.chillermate.com

Description: Promethean Energy, makes unique waste heat recovery (WHR) products for industrial and commercial purposes to help reduce heating costs by upto 75%. They recover waste energy from utilities like chillers and air compressors, convert it to zero-cost hot water and give it back to the industry. This offsets the fuel requirement for generating this hot water.

After having started work on this product 8 months back, Promethean have already installed the products in Godrej Industries and Aditya Birla Group. They have secured an LOI from a dairy in Maharashtra as well as a hospital in Delhi, apart from enquiries for close to 10 orders in the past month.

Wireless Occupancy Sensors for Eliminating Energy Wastage, BuildTrack – Surmount Energy Solutions

Applicable sector: Buildings in all sectors

- Conforms to NBC, IESNA, IGBC, GRIHA and USGBC Standards
- Switches will work, even if sensors fail or run out of battery
- Immediate return on investment
- No requirement of additional wiring
- Sensor can be freely placed where required, Single sensor can control multiple switches

www.buildtrack.in

Description: Occupancy sensors have long been considered a viable solution for reducing energy consumption in many residential and commercial settings. The challenges in implementing them in existing situations are many and these issues faced often deter from their usage in retrofit situations.

- Wiring that is visible stretching from every device needing to be controlled to the occupancy sensor which is both a cost and sore on aesthetics
- Difficulty in using a single sensor to sense occupancy and control multiple electrical devices (e.g. lights, fans, A/C)

The solution is a wireless occupancy sensor that "talks" to existing switches to operate electrical devices connected to them. The complementary device that enables the switch to "listen" to the sensor "talking" is a node that can fit behind most existing switches and it controls the switches. This solution consisting of the sensor and node work through wireless communication with each other with the sensor "talking" when it senses occupancy to inform the switch to "turn ON" and similarly to turn OFF once it senses that the occupant has left the space.

Iot Driven Smart Energy Analytics System

Applicable sector: Currently, the focus is on commercial customers of electricity including:

- Offices
- Hotels
- Hospitals
- Schools or college campuses
- Retail outlets

https://zenatix.com/

Likely impact: Zenatix has delivered 10% or more energy savings to more than 40 customers. Zenatix does not charge any Capex for deployment of its hardware or software. The customers are billed a fixed subscription fee (per month or per annum) based on the size of the infrastructure. The energy savings delivered by the solution is to the tune of 2 to 4 times the subscription fee.

Description: Zenatix, co-founded by alumni from IIT Delhi, IIM Ahmedabad and UCLA, provides an IoT driven energy analytics product that helps commercial consumers of electricity save at least 10% energy using intelligence from the energy data.

The product is a combination of hardware and software. The hardware includes sensors (smart energy meters, temperature/humidity sensors) and Zenatix controllers that acquire data in real time from these sensors. It is understood that raw data doesn't drive a change. Therefore, Zenatix software delivers actions or insights in form of automatic control or sms/email alerts. The actions or insights are based on analytics based use cases that Zenatix has developed for different kinds of electrical loads. The software also includes dashboards which allow customers get an understanding of consumption patterns in real time.

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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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