Training of Trainers Workshop on Dissemination of Japanese low carbon technologies in India

20th January 2017 at Pune

Organised by

The Energy and Resources Institute (TERI)
Institute for Global Environmental Strategies (IGES)
Maharashtra Energy Development Agency (MEDA)

With support from

Ministry of the Environment, Government of Japan (MoEJ)

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Summary

Training of trainers workshop on 'dissemination of Japanese low carbon technologies in India' was organised on January 20, 2017, at Hotel Crowne Plaza, Pune by TERI in collaboration with Maharashtra Energy Development Agency (MEDA). The event was supported by 'Institute for Global Environmental Strategies' (IGES), Japan. The agenda of the Training of trainers (TOT) workshop is given in annexure 1. A summary of the deliberations of the Training of trainers workshop is given below.

Session-1: Inaugural

Mr Girish Sethi, TERI welcomed the Japanese experts from IGES and Hitachi. He gave an overview of Japanese energy efficient technologies (LCT) for industries and development of JISMAP (Japan India stakeholders matchmaking platform). He mentioned that the Japanese technology companies/manufacturers are looking into market issues like costs and other resources which will absorb the Japanese technology and various benefits which will be realised through its implementation and replication of implementation. He mentioned about the oil crisis and how Government of Japan supported overall growth in the country with keeping business needs and policy developments in Japan. He explained about the aim of the todays TOT workshop, which basically focussing on "compressed air technology" and requested participants to take it forward for training colleagues and engineers. He also shared about the development of website of Japan India Stakeholders Matchmaking Platform (JISMAP) which will showcase the case studies, feasibility reports, potential Japanese technology suppliers and key applications etc.

Mr Hemant Patil, MEDA, welcomed Japanese experts and participants of training program, later He thanked TERI and IGES for organizing the Training of trainers workshop at Pune. He mentioned that the Japanese technologies are quite costly, which of course Japanese manufacturer might be working on reducing the costs but the facts remains that the benefits accruing due life cycle are important. He mentioned that PAT cycle-1 already completed and now it will be challenging for industries to achieve the targets given in cycle-2. He requested TOT participants to understand the advanced features of Japanese LCTs. On the JITMAP, He mentioned that this website will be helpful for getting more information for the deployment of technologies. He mentioned that the participants should interact with Japanese experts. He said that MEDA is developing energy conservation policy and funds scheme, which will be made available for EE projects particularly on ESCO basis. Regarding the Training of trainers workshop he suggested to cover wide range of sectors and technologies for capacity building like this TOT workshop and initiating demonstration projects of the Japanese technologies. Later he thanked once again to TERI and IGES for organizing the Training of trainers workshop and he also thanked participants.

Dr Rabhi Abdessalem, IGES provided an overview about IGES and the IGES-TERI association in India, which has provided support to bring in technologies from Japan and visit select site in India for conducting feasibility studies, business to business matching. He mentioned that in order to move fasters for initiating the technology identification and implementation on the ground, JITMAP website is being developed to bridge the gap of information and culture amongst each country. He mentioned that key activities includes assessment, technology option, matching the stakeholders and up scaling the activities through awareness workshops and TOT workshops. He mentioned such kind of TOT workshop have been organized first time here in India to train the trainers on Japanese low carbon technologies. Under the project and association of IGES & TERI, more focus is on industry (buyers) to match/collaborate with the appropriate suppliers of Japanese technologies. He

mentioned that application of LCT has good potential in Indian industries and could be implemented by various strategies. He also mentioned that the overall efforts of IGES & TERI shows that there is need for creation of the JITMAP platform for Japanese LCTs for business matchmaking and hence an website which is under development will help to promote the LCT by showing case studies, technology specifications, suppliers details etc. A copy of his presentation is provided in Annexure 2.

Session-2: Technical- Optimization of compressed air systems – Japanese experience

Mr Saito Tsukasa, Compressed Air System Expert, formerly with Hitachi Industrial Equipment System Co. Ltd, Japan, started his training presentation with CO2 emissions & GDP of various countries like China, USA, India etc. A copy of his training presentation is provided in Annexure 3. He mentioned that emissions are high because energy consumption is high. Some of the highlights of his training are given below:

- The percentage contribution of energy consumption by air compressors in the Plants is 5 to 25% and potential savings is quite higher.
- For air compressors life cycle, the operating cost on energy is 84%, 7% for initial investment and 9% for maintenance of the air compressor.
- He stated that there is three ways for using air compressor efficiently – Reduce the consumption of air, reduce the air pressure and optimize the air compressor.
- Pipe size – thinner size should be checked. For reduced pressure loss without large no. of bends should be avoided. Air with 4 – 5 m/s of velocity should be considered but if the piping cost is too high then 15 – 20 m/s of velocity could be considered for calculation of pipe size. Types of valves ball valves and globe valves, in globe valves there are 60% more losses than gate valves.
- Piping should not be underground and drain valves should be placed at lower position in pipelines. The filter size should be adequate so, that there is no pressure drop. Higher resistance causes pressure drops and also there is overloading of the air compressors resulting in frequent breakdowns. Piping should be used in looping for reduced pressure drops.
- If the suction air temperature is high then energy consumption will increase.
- Check on Load/unload of air compressor, running hours, leakages etc.
- For variation in air requirement is from 20 to 80% that use of inverter type air compressors is important, as industry though are using inverter compressor are not getting desired energy savings. The continuous air compressor should be used at base load and inverter compressor should be used for variable load with proper pressure setting.
- Hence, control system if of importance while selection of inverter type air compressors.
- If adequate and large receiver size is used, there is energy saving about 3%. Proper ventilation of air compressor decreases the surrounding temperature resulting in less stoppage due to over temperature and energy saving with less inlet temperature. For indirect ventilations large size fans are required. Proper layout of air duct is required for ventilation. For various air pressure requirements in the plant, pressure boosters or booster air compressors can be used, which will eliminate the high-pressure generation at main air compressor.
- Pressure measurement on real time basis is key for energy savings as many problems occurs due to fluctuations in every day. Once the pressure measured in real-time many problems in the system related to pressure loss, quantity of air, volume of air tank, looping of air piping etc. can be solved.

- Pressure reduction by 1 bar will give energy saving of 6-8%. Use of proper air nozzles for blowing will reduce the air consumption. Leakage test can be carried out frequently to check the quantity of air leakages in the plant. The physical verification at joints of hoses, couplers will help to identify the air leakages, even soap solution can be poured at the joints for checking the air leakages.
- At many places it is observed that even if the air compressor replaced with 10% higher efficiency but still energy consumption increased which is due the pressure being not monitored in real-time and pressure settings/fluctuation not delivered energy savings.
- It may also be possible sometimes energy is saved and sometimes energy not saved. Hence cross point can be changed according the pressure graph plotted based on the real-time measurement.
- Multiunit control can be used at the air compressor installations having more than 2 air compressors. Etc. He explained advantages/disadvantages of centralised and de-centralised air compressor systems.
- Selection of air compressors, less investments leads to lesser savings and for higher savings higher investment should be calculated based on the life cycle and it may provide basis that investment in the beginning leads to large amount of benefits hence good calculations provides right results.
- IE5 motors efficiency is above 95%
- He briefed about various examples while mentioning points above. Plan/do/check/act is continuously required for energy efficiency requirement in compressed air system.

Session-3: Technical- Optimization of compressed air systems – Japanese experience

Mr Chetan Sangole, TERI, moderated the interactive session for questions & answers about the TOT on air compressors. The following points are summarised based on question answers:

- Questions were raised for
    - capacity of air tanks, location of air tanks,
    - pipe sizing according to air compressor capacity,
    - speed control in oil free air compressor,
    - WHR from heat of air compressors,
    - air savings valves,
    - Efficiency of mechanical boosters and electrical boosters etc.
- Mr Saito Tsukasa, Compressed Air System Expert, formerly with Hitachi Industrial Equipment System Co. Ltd, Japan, started answering the questions one by one and interacted with participants. Some of the highlights of his answers are given below:
    - Capacity of air tank depends on the capacity of air compressors, to calculate it air compressor capacity to be multiplied by twenty.
    - 4-5 m/s velocity may increase the pipe and thereby cost but air velocity of 15-20 m/s may be used.
    - Minimum loss in inverter of Japanese make air compressors is maximum 3%.
    - Surge vessels might be useful to reduce pressure variations. In Japan, air tanks sold more than air compressors.
    - Location of air tanks depends on the air piping network design like lengths, size etc. and is more customized solutions which varies from industry to industry.
    - For oil free air compressors speed control up to 50% is appropriate and for oil flooded air compressors speed control up to 20%.

- In Japan, there are heat exchangers (WHR systems) being used to recycle heat from air compressors jacket and the heat is used for heating the rooms, heating swimming tanks, preheating boiler feed water etc. Heat exchanger used for oil free air compressors provides much better feasibility.
- Air compressors capacity should be decided based on the collective air quantity required for all usage points and considering 25-30% of it for sizing of air compressors.
- Pipe size should be appropriate enough as per technical calculation and not cost of piping and friction less pipe material should be used.

- The question and answer interactive session closed with vote of thanks.

Matchmaking of Japanese technologies through proposed on-line platform JITMAP – way forward

Mr Girish Sethi, TERI, moderated the session for sharing the insights of the TOT workshop and JITMAP website. He mentioned that TERI would like to collaborate with MEDA for developing industrial clusters, training programs, ESCO projects, demonstration projects etc.
He requested participants to share about their experience and expectations on energy efficiency and technology.

Select points of feedback and way forward:

1. It was appreciated by participants that vary deep insights has been covered under the training program and which will definitely help participants to train other colleagues.
2. The selection of technology/topic of 'compressed air system' training helps as almost every industry uses air compressors.
3. The Indian industries also needs support on technologies like refrigeration system, air conditioning, air washers, AHUs, CTs, WHRs, energy efficient burners, boilers etc.
4. This kind of TOT workshop should be organized in various industrial areas of MIDC like Taloja, Pataganga, Ranjangaon, Navi Mumbai etc. This may help business to business match making.
5. Funding for the appropriate projects for implementation should be given though for the Japanese technologies.
6. Indian industries are in need of high energy efficient technologies but industries are not aware and clear about the cost and implementation strategy of such technologies.
7. Implementation barriers like feasibility survey/audit studies may be overcome but convincing management is important and need more training about the technology feasibility and financial feasibility.
8. Sustainable reporting along with annual reports are being prepared by many industries/organization and focus could be on them for awareness and business to business needs may help for JITMAP

Mr Hemant Patil, MEDA, highlighted the aim that building capacity of energy managers & energy auditors under is important through such TOT workshop and MEDA support is available to TERI & IGES in the interest of Maharashtra's energy savings plan and emission reduction. Technology penetration potential exists and it should be part of services of energy auditing. He mentioned that clarity in business to business partnership is important and conversions of opportunity in business is also equally important. MEDA can enlarge walkthrough energy audits services through empanelled energy auditing firms and may also consider various proposals for technology implementation if

ESCO mechanism is promoted. MEDA may also support similar training programs of TERI & IGES under JITMAP as there is enough confidence in Japanese technologies.

Concluding remarks

Mr Rabhi Abdessalem, IGES, concluded the JITMAP project provides activities on the ground like conducting feasibility studies and training programs. He mentioned that they will continue to support feasibility studies and training which could be taken in another clusters and area. On finance he mentioned that financing is not problem but how to develop project and how to approach for finance is key. He mentioned that in this hall all stakeholders like industries, technology service provider, ESCO, MEDA, TERI and IGES are present and once we agree on specific project and payback then it is possible to expedite the process of implementation. He shared about the matchmaking of business on LTCs and how feasibility studies provides values of parameters like energy savings, payback etc. He mentioned that there are active discussions from the Govt to Govt and also this project provides key inputs at policy level to overcome barriers in promotion of Japanese LCT. He also mentioned that case studies may help for the way forward for win win situation.

About 42 participants like energy managers from industry, energy auditors from auditing firms, government organization, and ESCO organizations participated in the TOT workshop.

Some photographs of the event are provided in Annexure 4.

Annexures

Annexure 1: Agenda of the Training Program

Training Program on

Japanese low carbon technologies and best practices

Friday, January 20, 2017, 10:00-16:30 hrs
Crowne Plaza, Bund Garden Road, Next to Jehangir Hospital, Pune 411001

Organised by

The Energy and Resources Institute (TERI)
Institute for Global Environmental Strategies (IGES)
Maharashtra Energy Development Agency (MEDA)

Supported by

Ministry of the Environment, Government of Japan (MoEJ)

Objectives:

- To generate awareness about Japanese energy efficient technologies amongst Indian industries
- To provide training to energy managers & energy auditors
- To explore possibilities of strengthening Indo-Japan cooperation through JITMAP

Agenda

10:00 - 10:30 hrs	**Registration**
Session 1: Inaugural Session	
10:30 – 11:00 hrs	**Welcome Address** **Mr Girish Sethi,** Senior Director, The Energy and Resources Institute (TERI) **Mr Nitin Gadre,** IAS, Director General, Maharashtra Energy Development Agency (MEDA) **Presentation on IGES-TERI's efforts to promote LCT deployment in India with special emphasis on initiating Japan-India technology matchmaking platform (JITMAP)** **Dr Rabhi Abdessalem,** Senior Policy Researcher & Task Manager, Institute for Global Environmental Strategies (IGES), Japan
11.00 - 11.15 hrs	**Tea/coffee Break**
Session 2: Technical Session 1 – Energy efficient technologies	
11:15 – 13:15 hrs	**Training on 'Optimisation of compressed air systems & motors - Japanese experience' (Lecture)** **Mr Tsukasa SAITO,** Compressed Air System Expert, formerly with Hitachi Industrial Equipment System Co. Ltd, Japan
13:15 – 14:15 hrs	**Lunch**
Session 3: Technical Session 2 – Energy efficient technologies (contd.)	
14:15 – 15: 15 hrs	**Training on 'Optimisation of compressed air systems & motors - Japanese experience' (Interactive session)** Moderated by: **Mr Chetankumar Sangole,** Fellow, TERI **Mr Tsukasa SAITO,** Compressed Air System Expert, formerly with Hitachi Industrial Equipment System Co. Ltd, Japan
15:15 - 15:30 hrs	**Tea/coffee Break**
15:30 - 16:30 hrs	**Discussion on how to promote LCT deployment in India through Japan-India technology matchmaking platform** **Mr Girish Sethi,** Senior Director, TERI & **Mr Hemant Patil,** Manager, (Environment & Energy Efficiency) MEDA **Concluding remarks** **Dr Rabhi Abdessalem,** IGES

Annexure 2: IGES-TERI efforts to promote the application of Japanese low carbon technologies in India with special emphasis on JITMAP

IGES-TERI efforts to promote the application of Japanese low carbon technologies in India

Jan. 20th, 2017

Abdessalem RABHI, PhD.
Senior Policy Researcher and Task Manager, IGES

IGES
Institute for Global Environmental Strategies

About IGES: Outline

IGES

- **Name of the Institute**

The Institute for Global Environmental Strategies (IGES)

- **Establishment**
  March 31, 1998

- **Location**

>Headquarter: Hayama, Miura-gun, Kanagawa
>Tokyo Office: Chiyoda-ku, Tokyo
>Kitakyushu Office: Kitakyushu-city, Fukuoka
>Kansai Research Centre (KRC): Kobe, Hyogo
>Overseas Offices/Desks: India, Indonesia, Thailand and China.

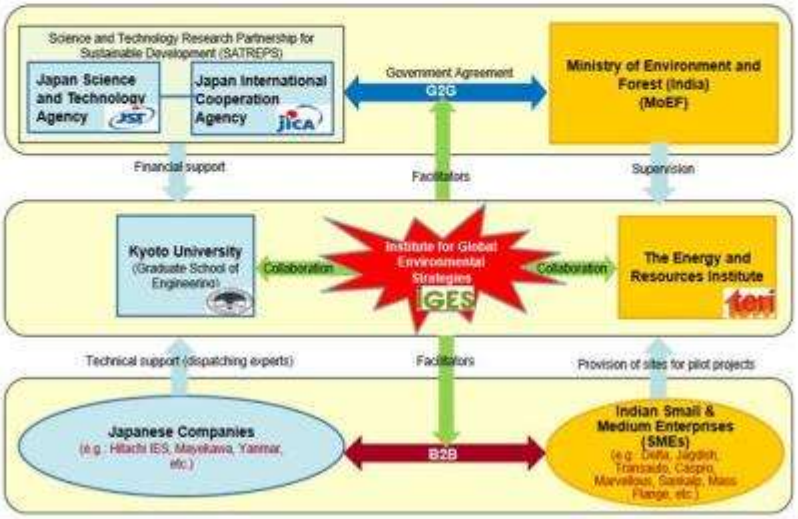
IGES headquarters (Hayama, Kanagawa)

Kansai Research Center | Date: July 7th, 2010 | 2

1. Project funded by JST and JICA (2010~2013)

Stakeholders

Under JST and JICA project, IGES and TERI (The Energy and Resource Institute in India) had successfully engaged and matched various stakeholders to promote Japanese low carbon technology application in India.



Activities: FS, DS and Pilot Projects implementation

IGES

Activities: Capacity building and awareness raising (level1)

Onsite capacity building for workers during site visits

IGES

Activities: Capacity building and awareness raising (level2)

Various cluster workshops to introduce technology to business entropreneurs and business associations

IGES – TERI Joint Workshop
(Dec. 2011, Rajkot (India)

IGES – TERI Joint Workshop
Jan. 2012, Chandigarh (India)

IGES

Activities: Capacity building and awareness raising (Level3)

Training workshops to Indian experts (training of trainers)

IGES

Activities: Capacity building and awareness raising (Level4)

Interaction with policy makers through meetings, symposiums, etc.

IGES-TERI workshop
(Feb.2012 New Delhi- India)

India-Japan Energy Forum
(Sep.2013 New Delhi- India)

Summary of "On the Ground" intervention

	Technology	Number of Onsite Feasibility Studies (FS)	Number of Pilot Projects (PP)
Hard Technologies	Gas Heat Pump	11	2
	Electric heat pump	13	2
Best Practices (Soft technologies)	Compressed air system	13	4
	Induction furnace	8	2

Results #1 : Demonstration of Electric Heat Pump (EHP)

- **Benefits**
  - Reduction in fuel consumption of boiler and electricity consumption of chiller
  - **Energy savings: 30%-40%**

Results #2: Demonstration of Gas Heat Pump (GHP)

- **Benefits**
  - Switch from electricity to Natural Gas
  - **Energy savings: 35%-45%**

Results #3: Demonstration of best practices on compressed air

- **Benefits**
  - Reduction in air consumption, in air leakage, hence in energy consumption
  - **Energy Saving: 20% -30%**


e.g:1: Installation of new receiver and new air compressors (not inverter type)


e.g:2 Adjusting pressure setting


e.g:3 Reduce air leakage through installing foot switch


e.g:4 Reconsider pipe size and design


e.g:5 Start the use of efficient air gun

Notes:
-Installation of inveter type air compressor at the sites could bring additional 10%-20% energy saving.

IGES

2. FY.2014-2015: Building up on previous achievement and strengthening partnership

1
3

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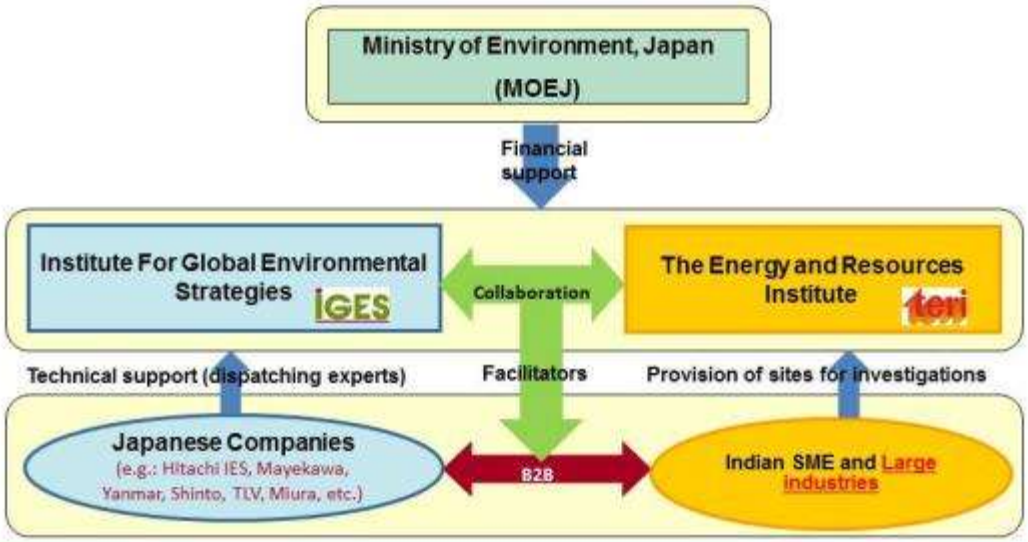
Projects funded by MOEJ (FY2014~2015)

Stakeholders

IGES and TERI built upon the previous achievement and engaged and matched more stakeholders while extending the focus to more technologies and to large industries



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Summary of selected technologies 2014 & 2015

	Technology	Number of onsite feasibility studies
Hard Technologies	Gas Heat Pump	5
	Electric heat pump	3
	Once Through Boiler	5
	Steam System Optimization	1
Best Practices (Soft technologies)	Compressed air system	10
	Induction furnace	2

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IGES

Engaging stakeholders

Matching Businesses to Businesses (B2B)

Investigation & capacity building: GHP

Investigation & capacity building: EHP

Investigation & capacity building: CA

Investigation & capacity building: IF

Investigation & capacity building: Boiler

Investigation & capacity building: Steam

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Engaging stakeholders

Matching Businesses to Funding Agencies (B2F)

Mtg. with Gujarat Energy Development Agency

Mtg. with Small Industries development bank in India

Mtg. with JICA (India)

Mtg. with Japan bank for International Cooperation (India)

Engaging stakeholders

Matching Businesses to Policy Makers (B2P)

e.g. mtg. with Local and Central Boiler Inspectors regarding boiler regulation

Key findings

- Huge potential/Market for Japanese low carbon technologies deployment in India however:
  - High upfront cost of Japanese technologies;
  - Significant information/knowledge gap exists;
  - Incomplete, fragmented, and uncoordinated efforts to tap opportunities;
  - Communication related (language, concepts, etc.)

- More efforts and resource should be allocated to creating opportunities to Japanese suppliers to interact with Indian end users (B2B), policy makers (B2P) and funding institutions (B2F);

- **It was concluded that there is a need to initiate a stakeholders' matching platform to address all the above in practical and systematic manner.**

3. Initiating a demonstrative matching platform (FY2016)

Matching Platform Concept

Note1: The matching platform has to be implemented/executed by a group of matchmakers, mainly non for profit organisations (NPOs), from supply and demand countries;

Note2: The matching is made through two forms:

- ***On the ground matching***: Through actual/direct interaction among stakeholders to conduct market assessments, feasibility studies, project proposals, demonstration projects, technical assistance and capacity building, loan syndication, Training of Trainers, PR and outreach, etc.
- **Online/Virtual matching:** Through collection, mapping and online sharing of relevant knowledge/information (online databases on technologies, policies, financing options, etc.), along with disseminating the findings/lessons learnt from the above on the ground matching.

Key feature of the platform

1) Practical: unique forum where matching B2B, B2F and B2P can occur on the ground as well as online.
2) Comprehensive: Information and knowledge sharing is about various aspects (technologies data base, policy data base, financing data base, etc. not just about one of them
3) Systematic: It addresses all the stages of Technology Transfer process, with special focus given to follow up activities.
4) Ultimate goal is to materialize the opportunities rather than just identifying them
5) Develop the information rather than just collecting it
6) It is not an alternative option to existing platforms, but rather a complementary one to them.

Key activities to be conducted under/by the platform

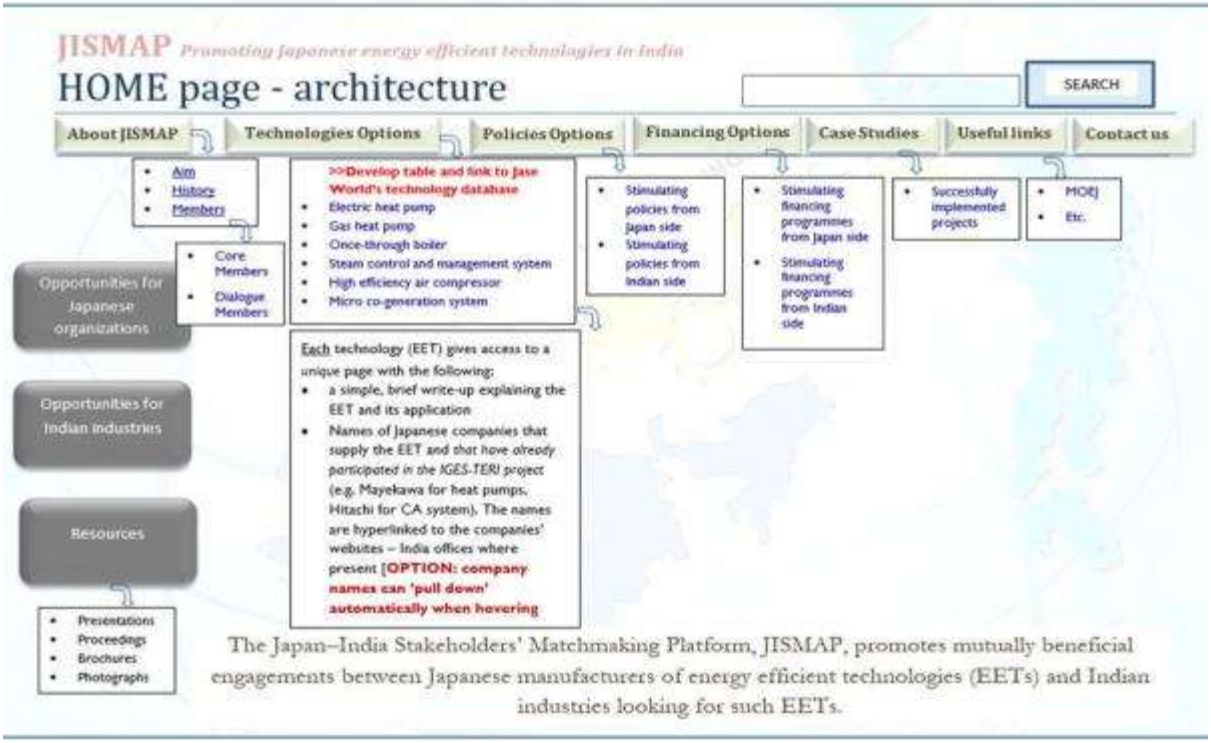
1) **Assessment & identification of seeds and needs (Technologies, Financing, Policies, etc.)**

2) **"On the ground" matching of seeds with needs** (based on the findings from 1)):
>Onsite investigations & feasibility studies along with Training of Trainers.
>Development, sharing and discussion of project proposals, and if necessary provision of loans syndications.
>Actual implementation of projects.
>Direct interaction of business with policy makers.

3) **Upscaling and technology diffusion (based on findings from 2):**
>Follow-up regarding the implemented projects to ensure their continuous operation.
>Identification and/or creation of opportunities at cluster/sector level.
>Explore replicability of implemented projects at cluster/sector level.
>Awareness creation and capacity building.

4) **Online Knowledge & Information sharing (based on findings from 1) 2) and 3).**

Sample of the online knowledge & information sharing directory/portal



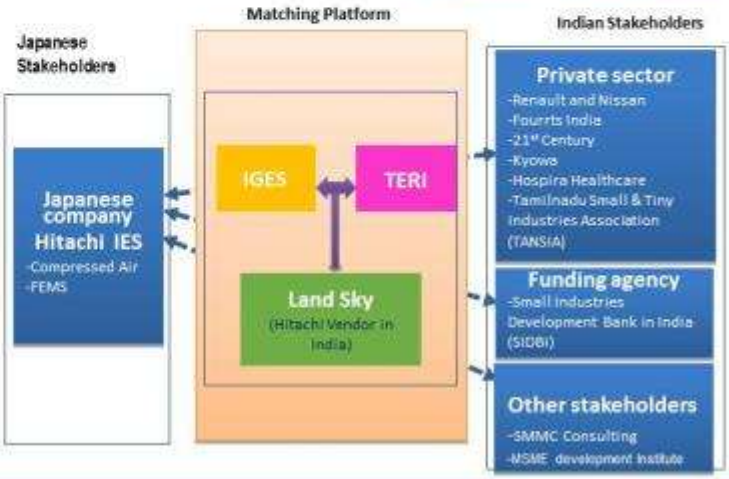
Progress and way forwards on Japan-India-Stakeholders Matching Platform (JITMAP)

1) MOU has been signed between IGES and TERI on July 13th 2016, and JITMAP has been launched as a trial basis;

2) During a business trip conducted on Aug. 21st - Aug.27th IGES and TERI, along with Land Sky, successfully matched Hitachi experts to several stakeholders as shown in the fig.

3) During a business trip conducted on Nov. 13-17, IGES-TERI and MEDA successfully matched TLV experts to several stakeholders.

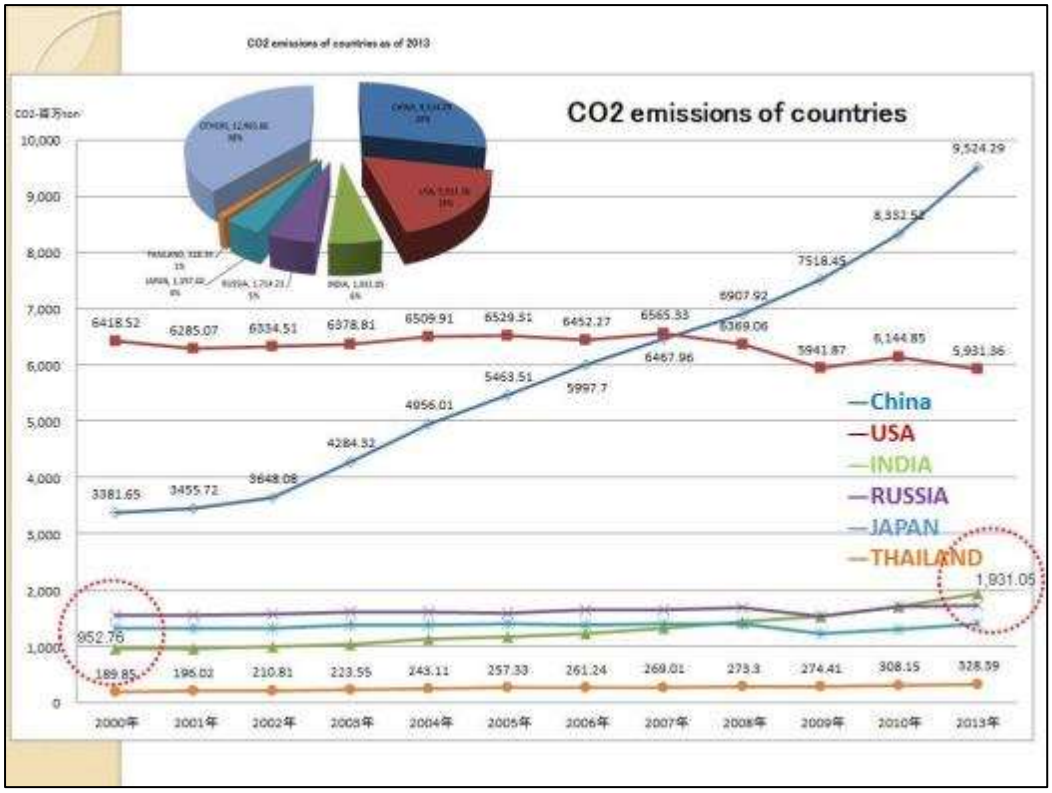
4) The online matching website is expected to be launched within January, 2016



Conclusion and way forwards

- There is no shortage of technologies, no shortage of funding, no shortage of efforts, but there is lack of coordination/synergy among efforts to develop projects;
- Key challenges to promote low carbon technologies in India include mainly:
  1) High upfront cost;
  2) Information/knowledge gap about the "needs" and "seeds";
  3) Communication related (not only language).
- Successfully matching Businesses-to-Businesses (B2B), Businesses-to-Funding agencies (B2F), and Businesses-to-Policy makers (B2P) could create synergy among efforts, fill part of the information/knowledge gap, alleviates part of overall business cost (through reduction of transaction cost, information cost, PR cost, etc.)
- To successfully match stakeholders, JITMAP could be considered as a good option. To this end, JITMAP should include adequate stakeholders along IGES and TERI.

Annexure 3: Optimization of compressed air systems – Japanese experience



Contents

- **Overview of compressed air system**
- Energy consumption & cost effectiveness
- Check points
- Energy saving measures – operational
- Energy Saving measures - technological
- Selection criteria
- Select Case Studies
- Energy efficient motors

Overview of compressed air system

Advantages:

- Easy to use
- Clean
- Air can be returned to atmosphere
- Quick movement
- Light & small actuator
- Safe if leak (no spark)

Hydraulic Power (Powerful)
Electric Power (Accurate)

- Volumetric
- Boil - Charles's Principle

$$\frac{P1V1}{T1} = \frac{P2V2}{T2}$$

(* P: Pressure, V: Volume, T: Temperature)

When volume decreases, pressure goes up.

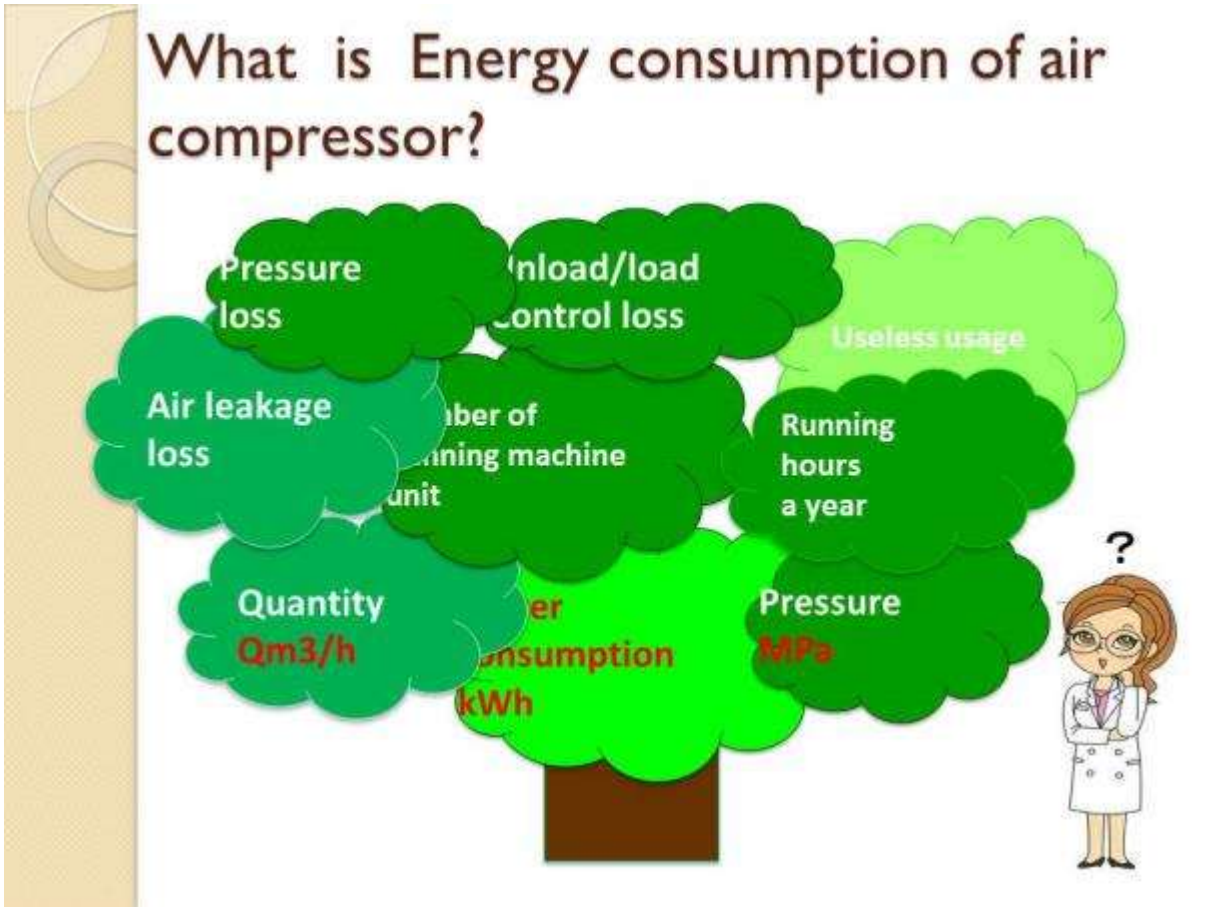
Piston 

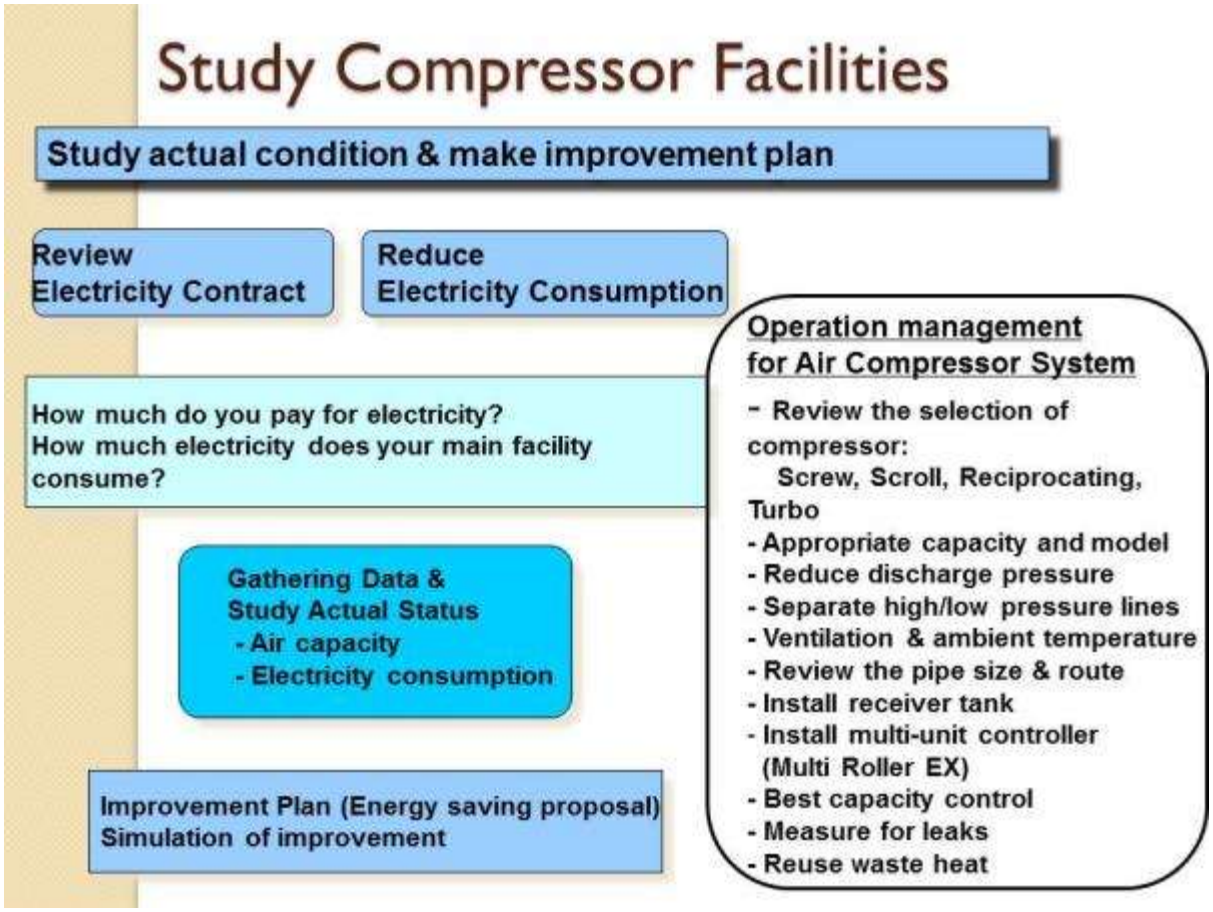
Screw 

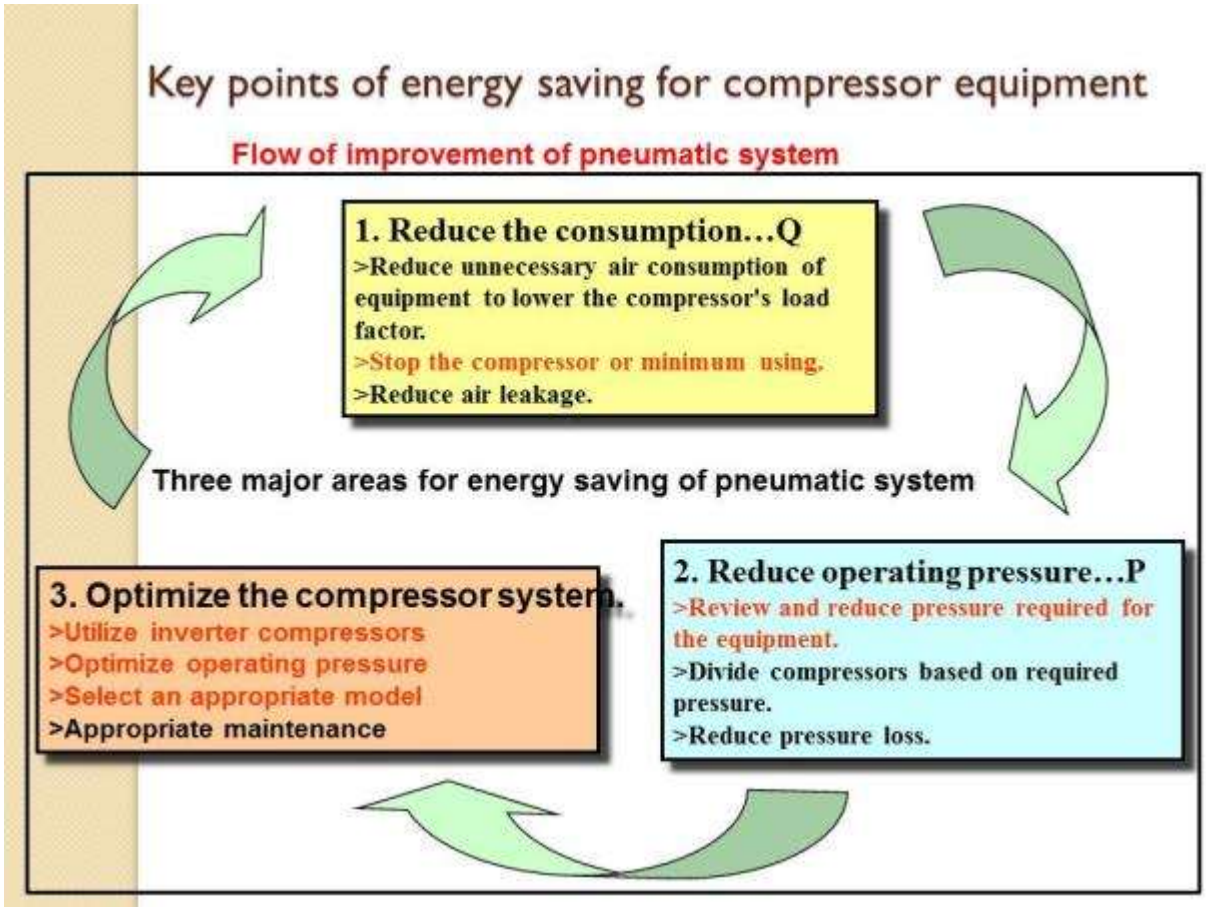
Scroll 

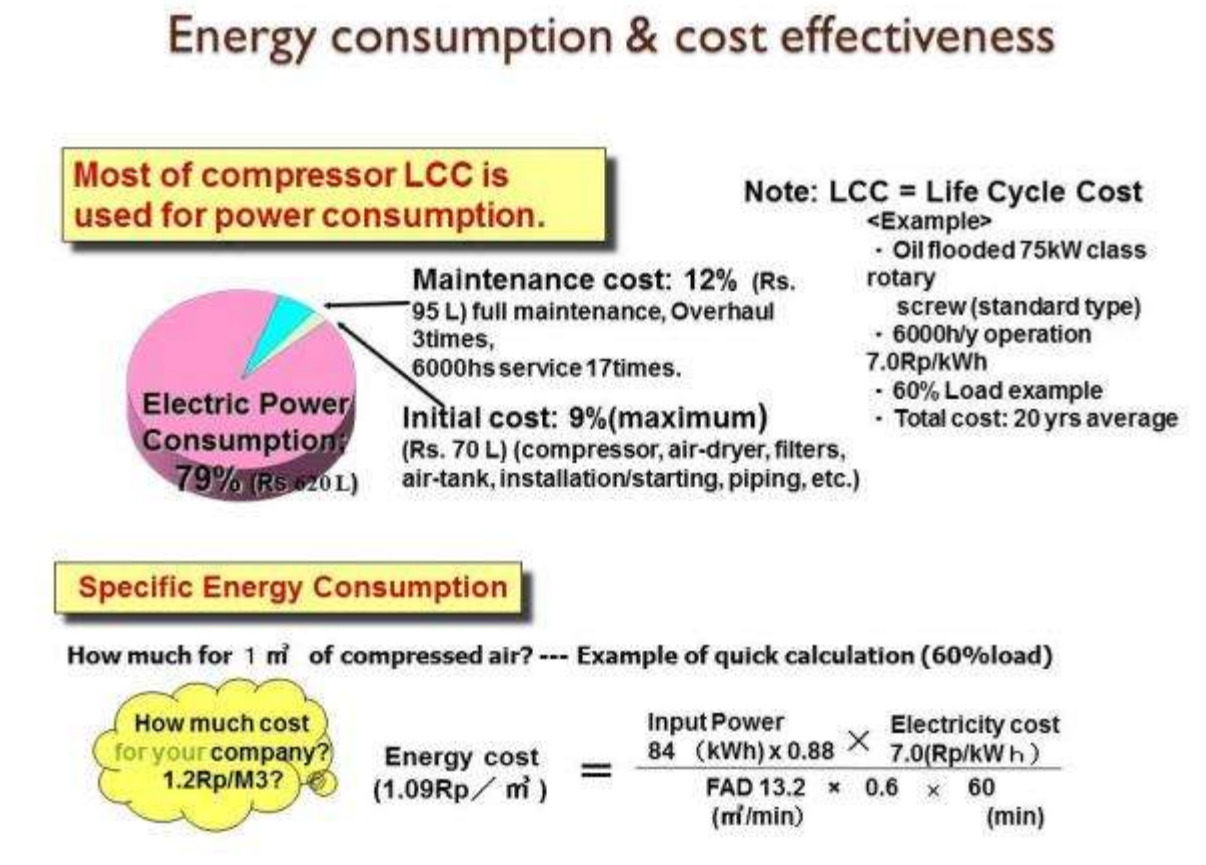
Applications

- Industry: Petroleum refining, petrochemical, steel, mining, automobile, electronics, food processing, pharma, etc.
- Commercial and transport: Wastewater treatment, cleaning, pneumatic tools, air brake system, elevators, etc.


What is Energy consumption of air compressor?
Pressure loss
nload/load
ontrol loss
Useless usage
Air leakage loss
ber of
ning machine
unit
Running hours a year
Quantity Qm3/h
er
nsumption
kWh
Pressure MPa
?


Study Compressor Facilities
Study actual condition & make improvement plan
Review Electricity Contract
Reduce Electricity Consumption
How much do you pay for electricity?
How much electricity does your main facility consume?
Gathering Data & Study Actual Status
- Air capacity
- Electricity consumption
Improvement Plan (Energy saving proposal)
Simulation of improvement
Operation management for Air Compressor System
- Review the selection of compressor:
Screw, Scroll, Reciprocating, Turbo
- Appropriate capacity and model
- Reduce discharge pressure
- Separate high/low pressure lines
- Ventilation & ambient temperature
- Review the pipe size & route
- Install receiver tank
- Install multi-unit controller (Multi Roller EX)
- Best capacity control
- Measure for leaks
- Reuse waste heat

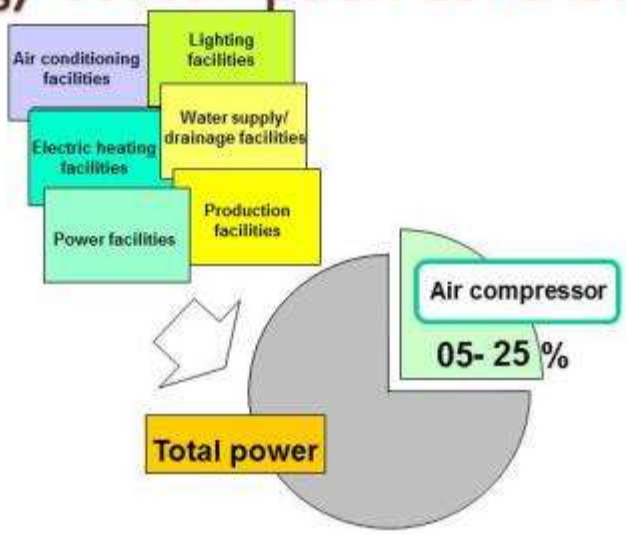

Key points of energy saving for compressor equipment
Flow of improvement of pneumatic system
1. Reduce the consumption…Q
>Reduce unnecessary air consumption of equipment to lower the compressor's load factor.
>Stop the compressor or minimum using.
>Reduce air leakage.
Three major areas for energy saving of pneumatic system
2. Reduce operating pressure…P
>Review and reduce pressure required for the equipment.
>Divide compressors based on required pressure.
>Reduce pressure loss.
3. Optimize the compressor system.
>Utilize inverter compressors
>Optimize operating pressure
>Select an appropriate model
>Appropriate maintenance


Energy consumption & cost effectiveness
Most of compressor LCC is used for power consumption.
Note: LCC = Life Cycle Cost
<Example>
・Oil flooded 75kW class rotary screw (standard type)
・6000h/y operation
7.0Rp/kWh
・60% Load example
・Total cost: 20 yrs average
Maintenance cost: 12% (Rs. 95 L) full maintenance, Overhaul 3times, 6000hs service 17times.
Initial cost: 9%(maximum) (Rs. 70 L) (compressor, air-dryer, filters, air-tank, installation/starting, piping, etc.)
Electric Power Consumption: 79% (Rs 620 L)
Specific Energy Consumption
How much for 1 m³ of compressed air? --- Example of quick calculation (60%load)
How much cost for your company? 1.2Rp/M3?
Energy cost (1.09Rp／m³)
=
Input Power 84 (kWh) x 0.88 × Electricity cost 7.0(Rp/kWh)
FAD 13.2 (m³/min) × 0.6 × 60 (min)

Contents

- Overview of compressed air system
- Energy consumption & cost effectiveness
- Check points
- Energy saving measures – operational
- Energy Saving measures - technological
- Selection criteria
- Select Case Studies
- Energy efficient motors

Energy consumption contribution



- Industrial energy consumption accounts for approximately 40% of the total energy consumption in India.
- Air compressors energy consumption share is approximately 5% to 25% in almost every industry
- Therefore energy saving for compressors needs to be addressed urgently.

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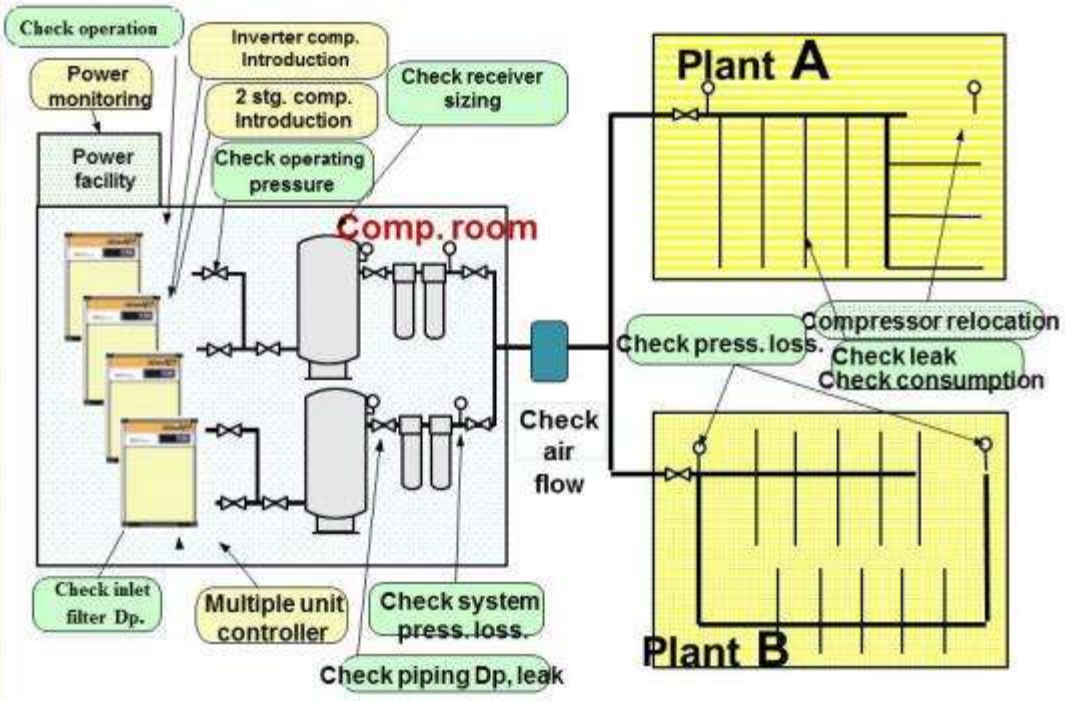
Check points in compressed air system



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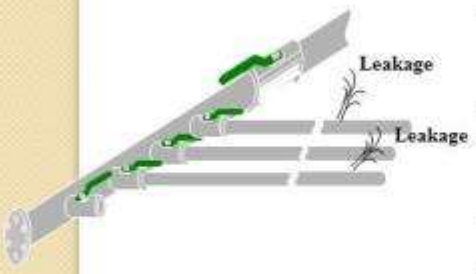
Energy savings measures - operational

- Leakages (savings 10 to 40 %)
- Pipe sizing & design (savings 7 to 20 %)
- Type and overall condition (savings 7 to 15 %)
- Pressure settings for reciprocating, screw type (savings 8 to 16 %)

Leakage Checking Method



- Leakage check is performed at night or on holidays when the plant is not in operation.
- Once the compressor is operated and raised up to predetermined pressure, stop the compressor and measure the time required for pressure reduction of 1bar from the predetermined pressure.
- Since all of this leads to waste of energy, quick actions are vital.
- It is possible to calculate the amount of leakage from the above investigation, then leakage locations need to be identified in the next step.
- Keeping that in mind, take measures from the most leakage prone areas.
- Leakage cannot be completely stopped with one-time measures.
- Continuous monitoring is required.

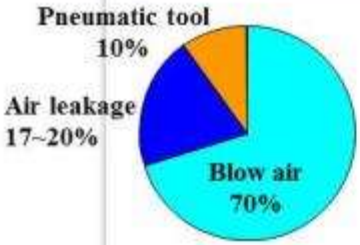
Places where air leakage is likely to occur

Valve | Blow gun | Regulator | Piping coupling

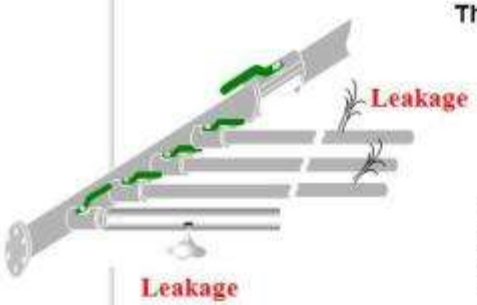
- Air leakage occurring as shown covers as much as 20% of the total average plants.
- The amount of leakage can be calculated by the formula in the next slide, after confirming, the same leakage areas can be identified and effective leakage reduction can be achieved.
- Target reduction is half of the total ratio.

How to Check Air Leakage?

Recommendation:
determine total leakage and reduce it by Leakage Checking Method



1. Operate compressor at night, or on a holiday, and shut it down when achieving a predetermined pressure value.
2. When the compressor is shut down, due to the leakage, the pressure will automatically decrease. The amount of leakage can be known by measuring the time (t) taken to decrease the pressure by 0.1MPa.



The formula to determine the leakage (C) is given below:

$$C = \frac{(P1 - P2) \times V}{Po \times t}$$

With:
C=Volume of leakage (M3/min)
P1= Predetermined pressure (MPa) (gauge pressure + 0.101MPa)
P2= Pressure after leakage (MPa) (gauge pressure + 0.101MPa)
t=Time taken to reduce pressure from P1 to P2 (min)
Po= Atmospheric air pressure(MPa)
V= Piping capacity (Mm3) (In case of your company; ? m3)

Effective Usage of Air

Mainly, usage of air is divided into; ① Air blow, ② Machine driving

① Air blow

◆ Consuming most air in a factory【No.1】
A continuous air sound used in a factory increases the amoun
air consumption considerably if having much air blow work ar
continuous use.
As for blow gun, a nozzle-type gun saves energy.

【Checking point】
① Diameter of air blow outlet... (consumption is "large", if the size is large)
② Pressure of outlet (supply pressure) ... (consumption is "large", if the pressure is high)
③ Time and frequency

② For machine driving (Actuator)

◆ The air used for "actuator (air cylinder)" driving isn't so large, but guarante
minimum pressure is required since it is needed to provide the power.

Note: Are【Supply pressure】and supply amount appropriate?

The air supply amount can be reduced by 30 % when installing air saving valve in the exhaust outlet of air cylinder.
Checking regulator's pressure gauge to confirm whether or not it can b decompressed.
Also, the consumption can be reduced by combining with air saving v

Environment of Compressor

Fresh
(Never install at such places !)

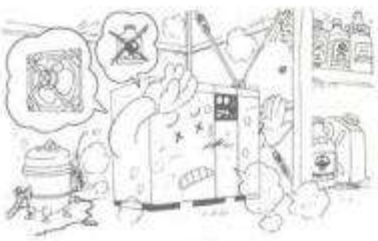
- If the air at the installation site is not good then the compressor cannot perform efficiently.
  - Harmful gases in surrounding area (corrosion, degradation, damage)
  - Dust, foreign substances (early damage, performance degradation)
  - Sealed room (reduction of air volume, temperature)
  - Near the sea (salt damage, corrosion)

Cold

- In displacement compressor, even if the suction temperature changes, air volume shown by suction status hardly changes.
  (Screw, reciprocating compressor)
- If (pressure and temperature) are same, with the lower suction temperature, the same amount of discharge air can be provided at relatively lesser amount of air suction.

Dry

- Part of the moisture in the suction air is condensed for draining and then it is discharged. Hence at higher humidity, amount of compressed air of compressor outlet can be reduced.



The performance is affected due to filter clogging.
5~10% effect on performance is perfectly natural.

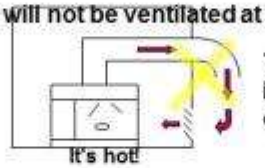
Specific gravity is approximately reduced by 11%
For low density air, qty is small.

Notes for Duct Installation Work

Provide a suction port low on the wall on the opposite side of the discharge port.

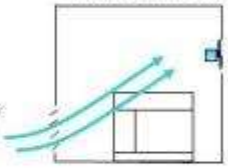
Be careful that the discharge port and suction port are placed on the same side.

In such a case, the room will not be ventilated at all.



Temperature increase trouble due to shortcut

Smooth air flow
Appropriate cooling

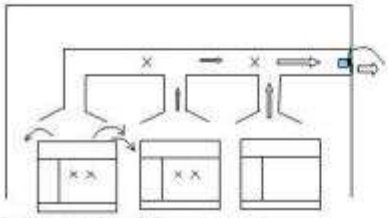


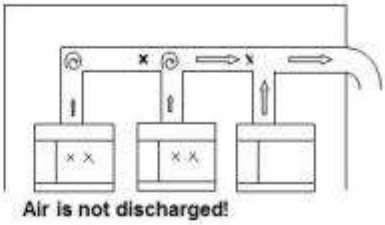
Be sure to provide a separate discharge duct for each compressor. Do not share a discharge duct for 2 or 3 compressors.

Air will not be discharged properly, leading to a failure.

The same rule applies when air is discharged through a duct using a blower or ventilator.

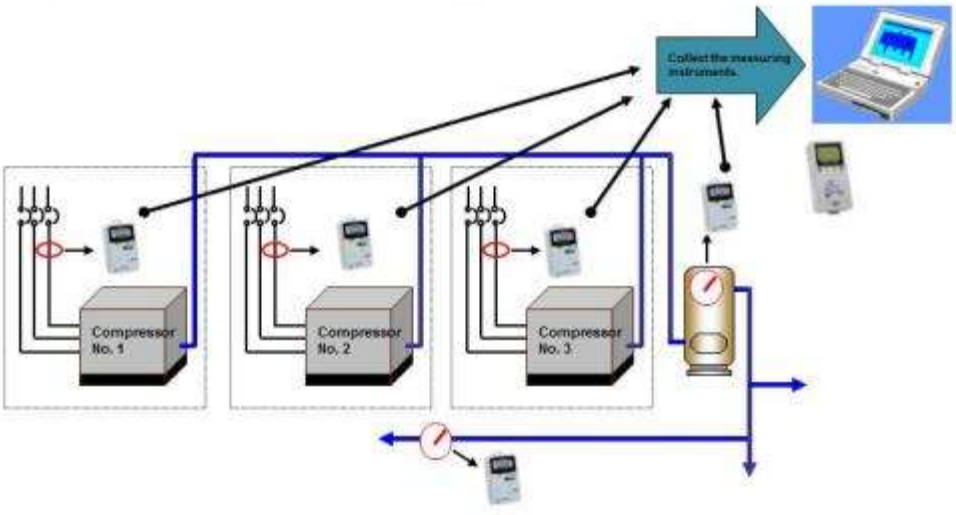
Even with forced exhaust, if ducts are combined into a single duct, balance will not be maintained. Overflowing discharge air may be taken into the neighbor machine.





Overview of Measurement Diagnosis

- Diagnostic procedure -
- Detect the current value of compressor using a current sensor and measure with a data logger.
- Detect the air pressure at the compressor outlet using a pressure sensor and measure with a data logger.
- Basically make the measurement for 7 days (168 hrs) to assess daily variations.
- Analyze the data measured by the data logger.



Measurement Diagnosis Procedure

Current value and air pressure measurement

(1) Connect the clamp (to one of the 3 phases).

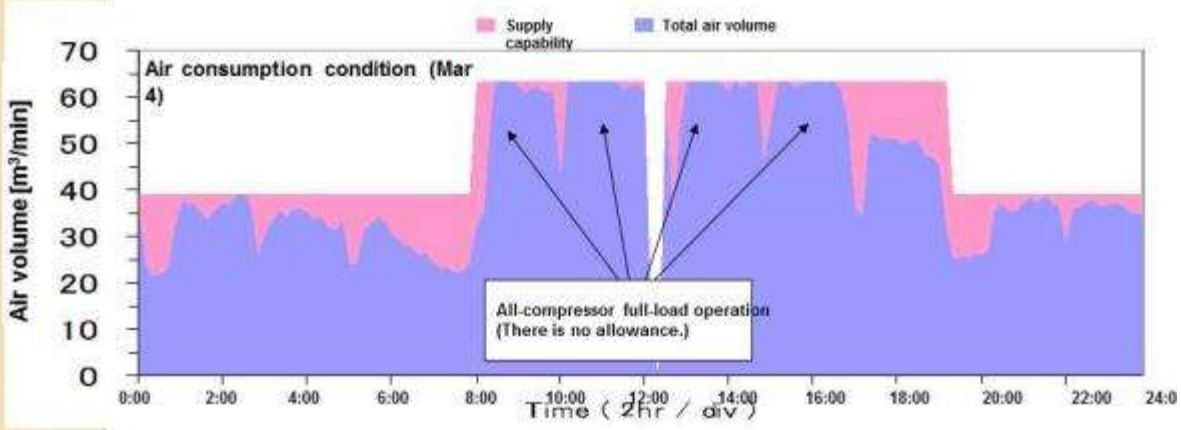
(2) Connect the cable and the data logger.

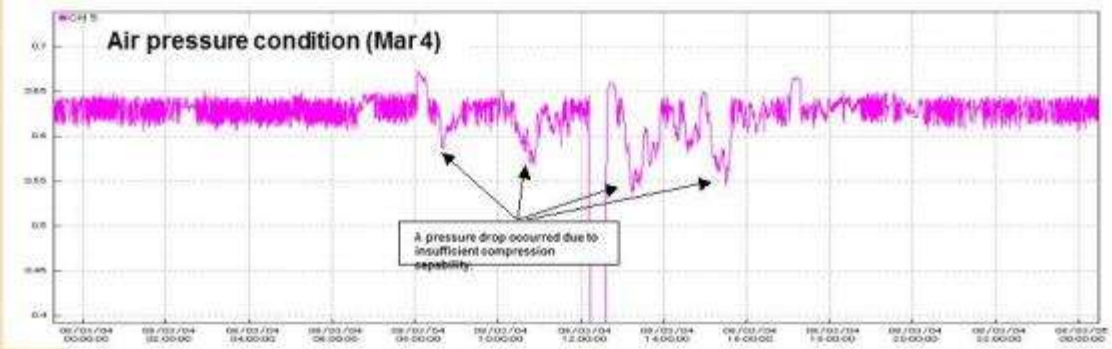
(3) Press the [Recording Interval] button and check the connection status.

(4) Check the pressure sensor mounting position (air receiver tank pressure gauge).
* A place where instant pressure fluctuation is small.

(5) Press the [Recording Interval button and check the connectio status.

Be Careful about Deficiency in Compressor Performance. - An Incorrect Proposal may Cause a Serious Trouble.

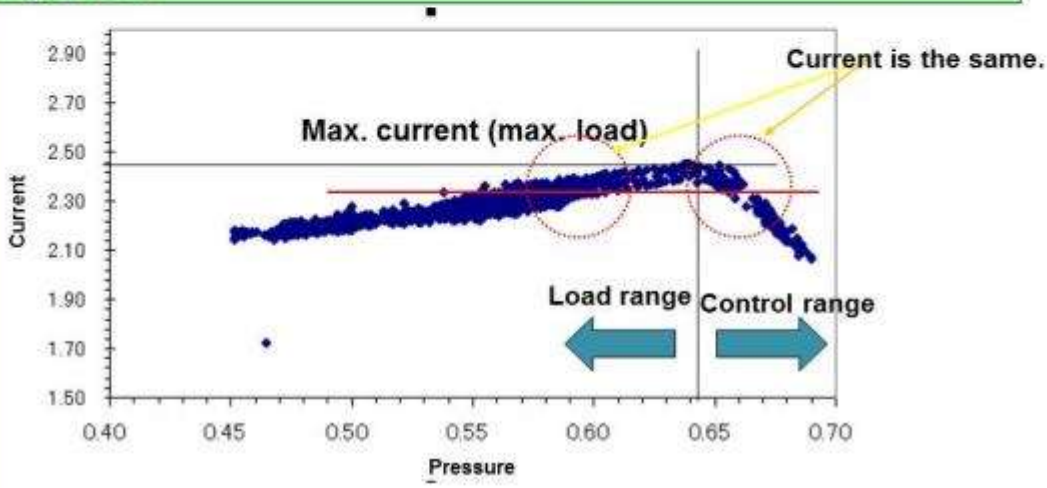




Care is Required for Measurement Diagnosis.

A measurement diagnosis was performed at the customer's required. As a result of data analysis, it was judged that unload was occurring because the current was low. A downsized model was proposed and immediately employed. However, pressure drop occurred, inhibiting the plant operation.

Cause: Misunderstanding of pressure fluctuation and power data - the state where air is lacking was misunderstood as unload. In reality, the pressure dropped due to the lack of air, and that state was maintained.
Action taken: It was determined that the machine would be replaced with a one-size larger model.

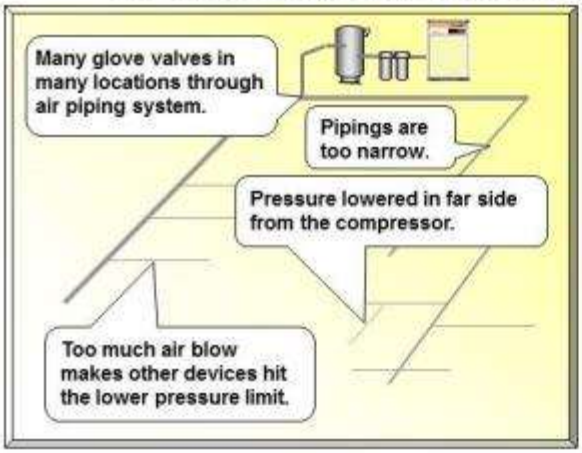


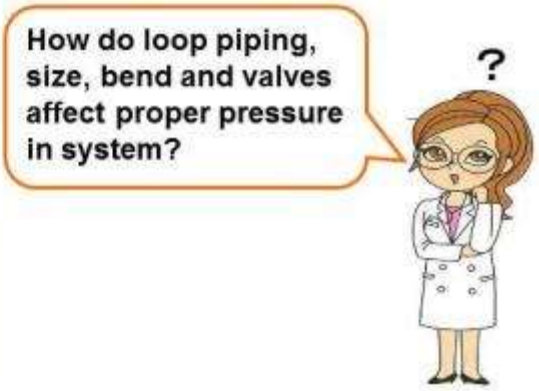
Pressure Optimization by Piping System Redesign

What is an efficient way to deal with local low pressure demand?
Do you have similar cases like this in your factory?

1. Un-stabilized factory air.
   [Status] Pressure on far side from compressor unstable.
   Pressure down when other systems are ON.
2. Due to budget allowance, no uniformity on air system such as devices, piping (size, route, valves).

What kind of improvement in this case?

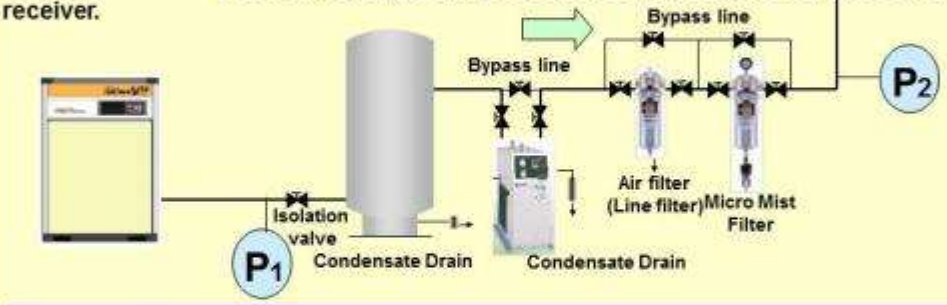


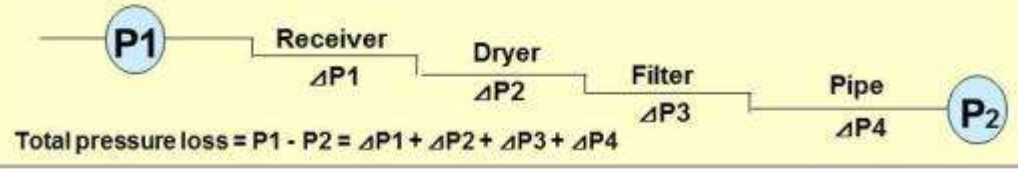


Pressure Loss of Compressor Equipment

Any system causes a pressure loss.
Think of how to minimize the loss.

Recommended layout (reference example): Compressor -> Receiver -> Dryer -> Filter
Point: This reduces the pressure loss between the compressor and the receiver.

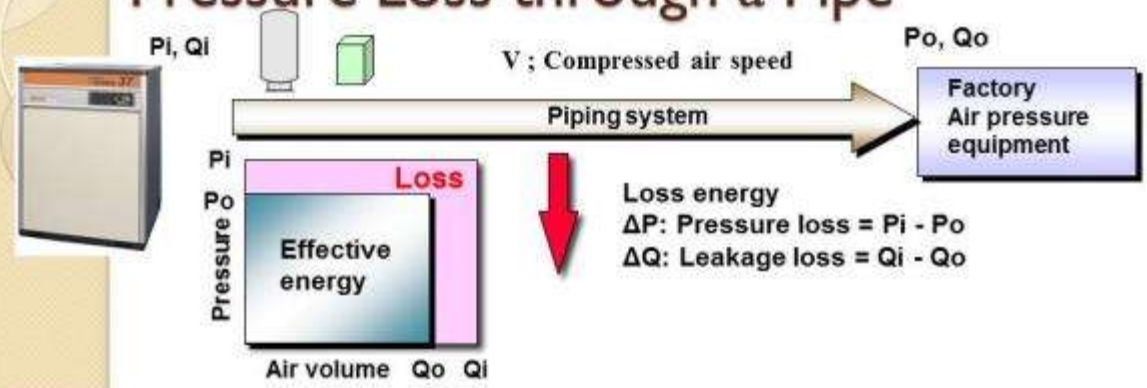




Total pressure loss = P1 - P2 = ΔP1 + ΔP2 + ΔP3 + ΔP4

To achieve a higher rate of energy saving, select a pipe having a diameter one size larger than the compressor's discharge pipe diameter. Also, select air dryers and filters having a capacity one size larger.

Pressure Loss through a Pipe



Loss energy
ΔP: Pressure loss = Pi - Po
ΔQ: Leakage loss = Qi - Qo

$$\text{Flow rate in the pipe } V\ (m/s) = \frac{Qi \text{ Compressor's discharge air volume} \times Ps/Pd}{A \text{ Sectional area of discharge pipe} \times 60}$$

The flow rate in the pipe is desirably 4 to 5 m/s. - Economic speed

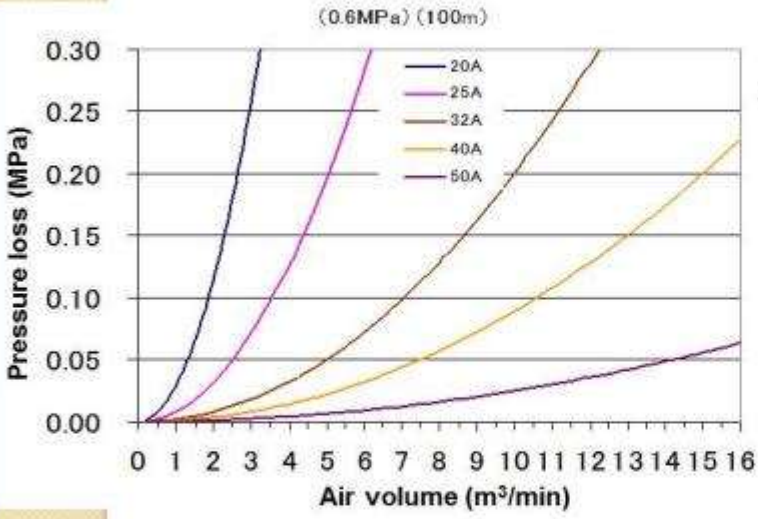
The smaller the pipe size, the higher the flow rate, causing a larger loss in the pipe. Accordingly an energy loss is generated, reducing the energy-saving effect.

- Example of 75-kW Air compressor(Japan Model)

(Discharge pressure: 0.69 MPa, discharge air volume: 13.2 M3/min), size of discharge air pipe: 50A

V = 13.2 x 0.101 / (0.101 + 0.69) ÷ 0.05 ÷ 0.05 ÷ 3.14 / 4 ÷ 60
= 14.31 m/sec (This is a very high speed.) The energy-saving effect is low.

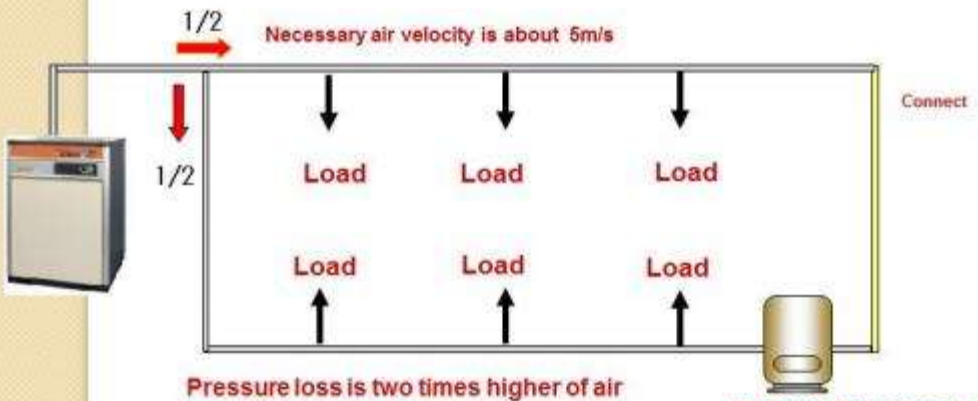
Let's Calculate an Appropriate Pipe Size.



$$\Delta P = 0.39\mu \times \frac{\ell}{d} \times \frac{\gamma v^2}{2g} \times 10^{-4}$$

ΔP Pressure loss (MPa)
μ friction coefficient
ℓ length of piping m
D diameter of pipe m
γ density of air kg/m3
(0.1013MPa, 0℃)
V speed of the air m/s
g The gravity 9.81m/s2

Changing air velocity through internal pipe ・・・ loop piping



Pressure loss is two times higher of air velocity in proportion

Pressure loss is minimized to one quarter, only to make loop piping!

How much improvement can be made with loop piping?

Pressure loss become one quarter, only to make loop piping if there is imbalance among load.

Pressure loss depends on valve types and shapes

Big loss・・・・

Gate valve is 40~60 times loss of pressure compared with straight pipe

7 pcs of glove valve(*** Valve)

Pressure loss caused by different types of valve

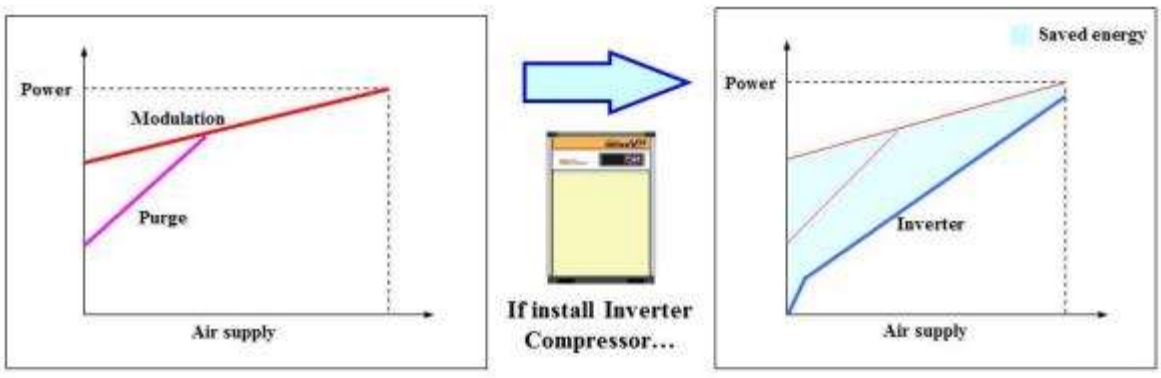
Contents

Energy saving measures - technological

- Replacement of existing air compressor with inverter type screw air compressor
- Introduction high pressure localization if compressed air requirement is at different pressures

Compressor Unloading Method Optimization – Inverter Drive

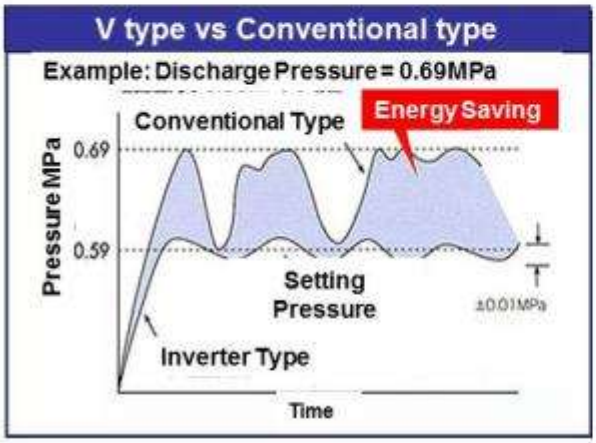
Conventional unloading method (modulation and/or purge) consumes unnecessary power during unloading. Inverter drive can save power!!!

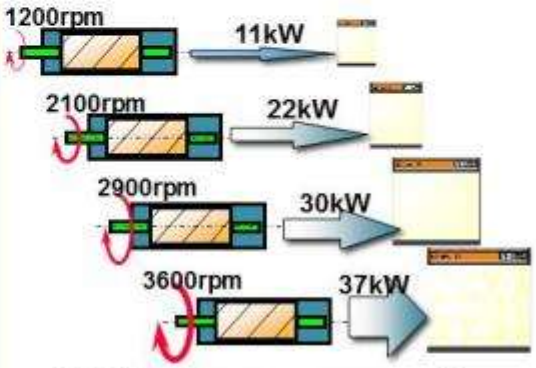


When you calculate the cost for several years, you can pay back the cost within 3 or 4 years.
(reducing power consumption=energy cost down=profit)
Not only reduction in energy but also protect the environment which reduces CO_2.

Inverter Type: Ideal Choice for Energy Saving

- Controls revolution of compressor according to the load
  No waste of power & ideal capacity control
- Operation with minimum pressure fluctuation
  Inverter type: Keeps the setting pressure
  Conventional type: Fluctuates around the setting pressure (*Refer to the below chart)
- Operation stops during unload
  Avoids waste of electricity (Conventional type runs during unload and consumes unnecessary electricity.)





37kW inverter compressor can be operated with 11kw class energy consumption

Example of Power Consumption Reduction with Inverter Compressor

■ Installation procedure

Energy-saving diagnosis of air compressor (Measurement of 37-kW conventional compressor x 1 unit)

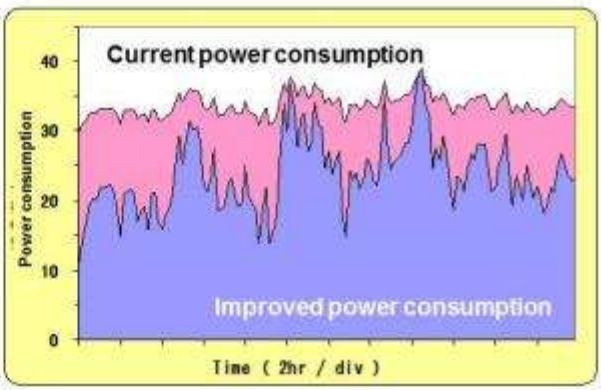
Diagnosis result	Improvement content
- Average load factor: 52% - Power consumption: 23,600 kWh/month	- 37-kW inverter compressor x 1 unit installed - 34% power reduction

■ Investment and effect

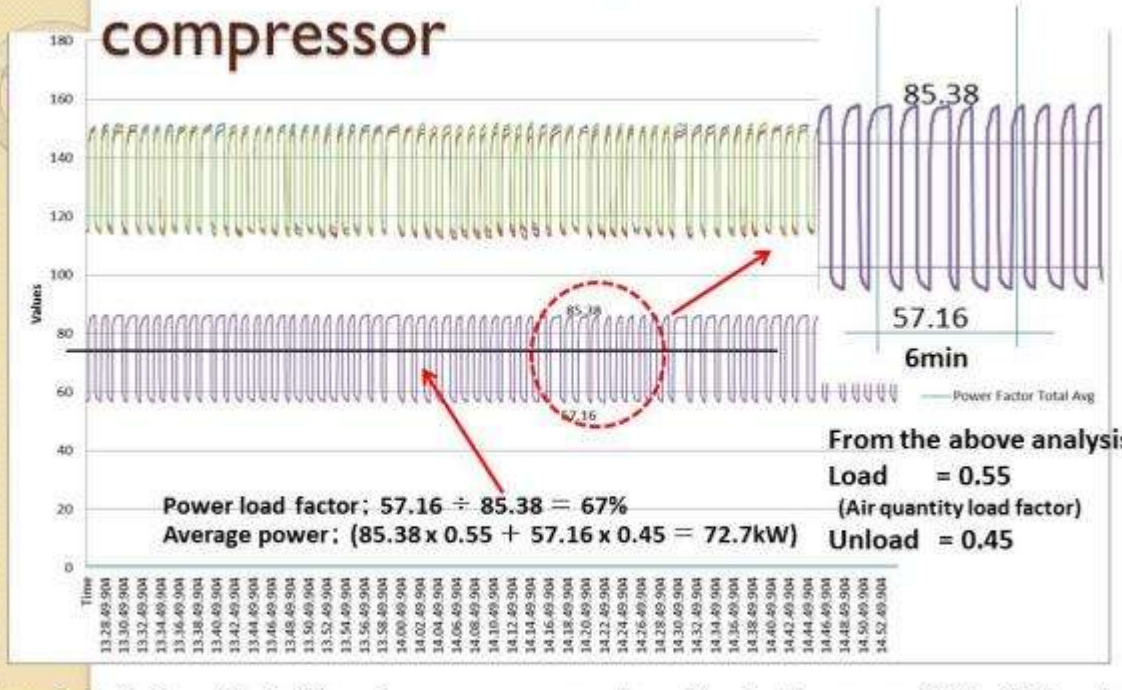
- Investment amount: 1.25 million INRfor a 37-kW inverter compressor
- Energy-saving effect: 0.55 million INR/ year

■ Spillover effects

- Investment in protection of global environment through CO_2 reduction (-34%)
- Investment in longer overhaul cycle (8 years) because of improved component durability, leading to reduced maintenance cost (-30%)



Present state analysis of 75kW compressor



Large installation effect of inverter compressor can be estimated because of ON – OFF control.

Energy-saving effect of change to inverter type

Characteristics diagram of foreign manufacture 【A】
⇨ Minimum power load factor 67% (Fix speed type)
Characteristics diagram of Japanese manufacture 【B】
⇨ Minimum power load factor 10 ~ 20% (VSD integrated type)

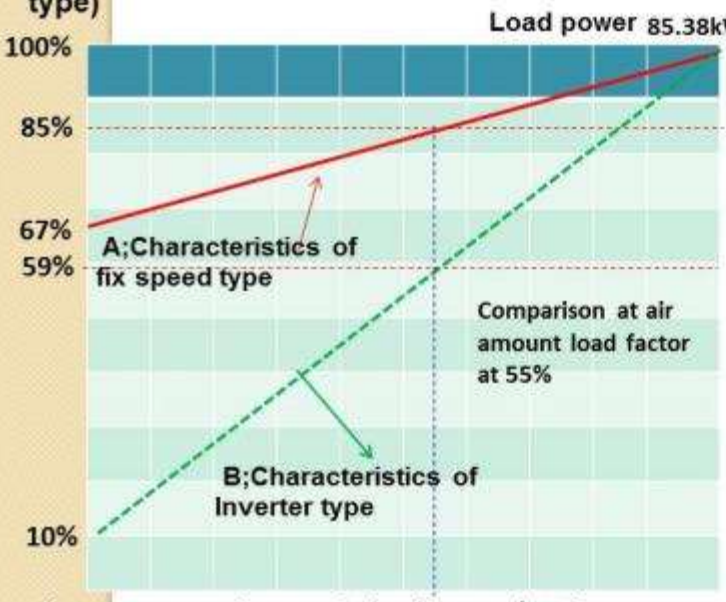


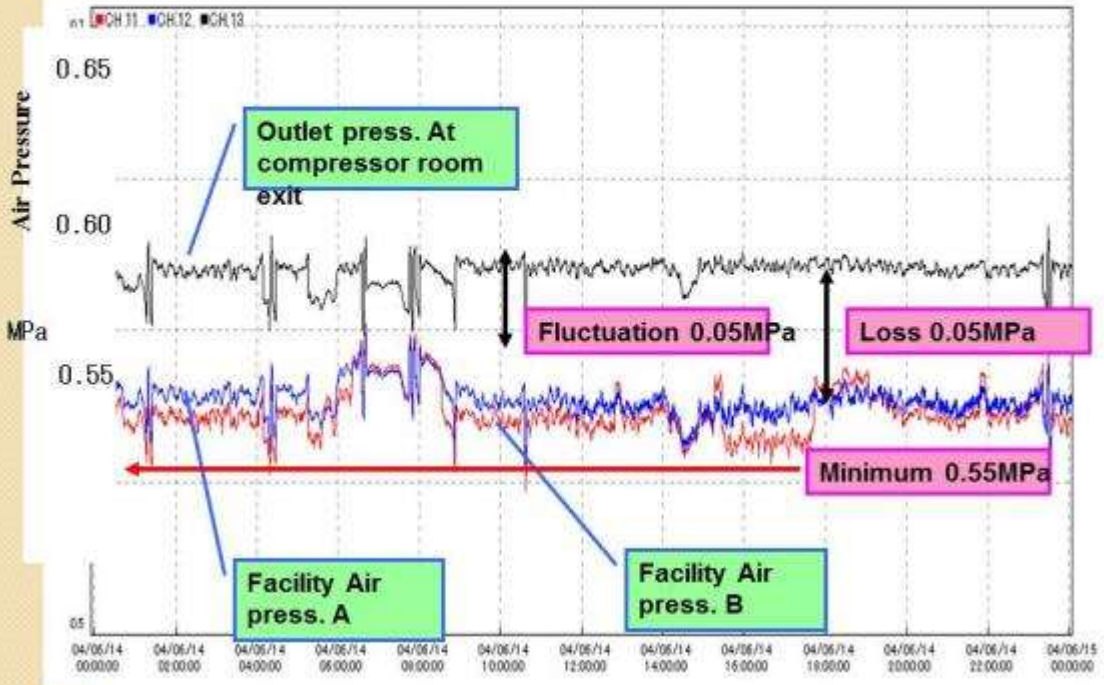
Figure ; power characteristics diagram (VS inverter type)

Estimation of energy-saving potential

1: Power load factor of fix speed is 67%
It is not energy saving.
2: Average air amount load factor is 55%
(Only load time is measured)
Power load factor at this time is 85%
3: Air amount load factor of inverter-type compressor is 55%
Power load factor at this time is 59%
4: 85.38 x (0.85 - 0.59) = 22.2kW
Energy - saving rate = 85 – 59 = 26%
5: If annual operating hours is set to 8,000h, energy saving of 22.2kW x 8,000h = 177,600kWh

(177,600kWhx7Rp/kWh=1,243,200Rp) can be expected. Approx. 174Ton of the reduction effectin CO2 conversion is

What to know? · · · Example of press. fluctuation a day



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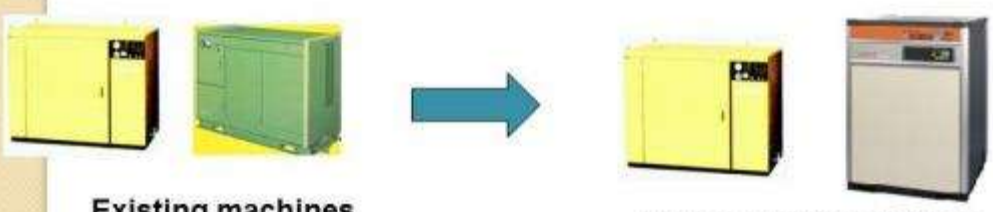
Example of Ending Up with Increased Energy Consumpti

One of 2 old machines was replaced with the latest model.
Because the latest model machine has a higher discharge air volume, it was operated as a base machine.
As a result, energy consumption increased approximately 10%.

Cause: The older machine was operated with capacity control. Because naturally it did not have good control characteristics, power consumption increased.
Action taken: Make the latest model machine dedicated for capacity control. As a result, approximately 20% energy saving was achieved.



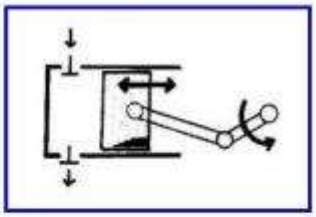
Existing machines

There was a need of energy saving.

Replacement machines

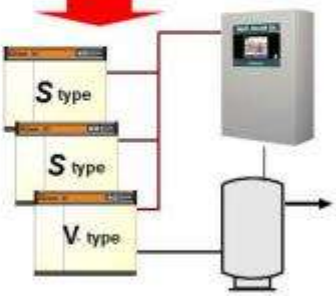
The highly-efficient inverter was operated as a base machine.

Concrete Proposal Example



160 kW SCREW

150kW RECIPRO



Proposal 1: Use of large two-stage compressor OSP-160S5WT

case1
Energy saving 28%

Proposal 2: Use of 2 inverters + Alternate operation panel OSP-75VW x 2 units

case2
Energy saving 46%

Proposal 3: Multiple unit control + Use of inverter OSP-55SA x 2 + 55VA

case3
Energy saving 20%

Concrete Example of Failure

- Example of a Manufacturing Company

What was the cause of failure? Identify the cause.
- Learn from the failure to do it better the next time.

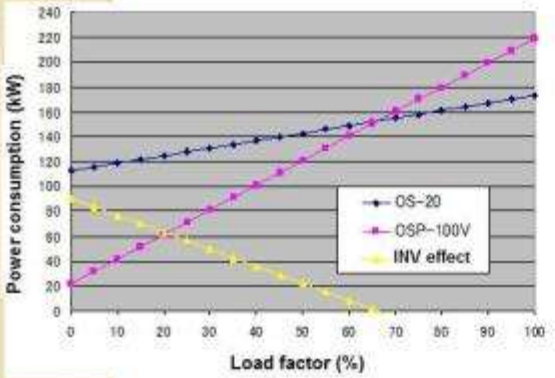
Dividing, use of inverters, replacing

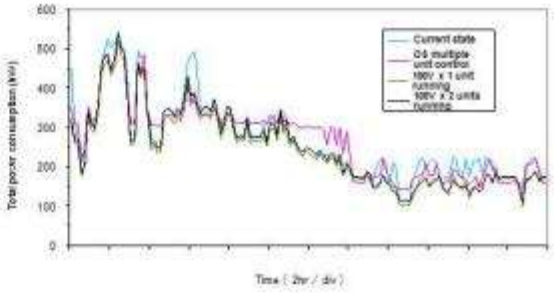
200kWSCREW (35.0 M³/min)

Ended up with increased energy consumption

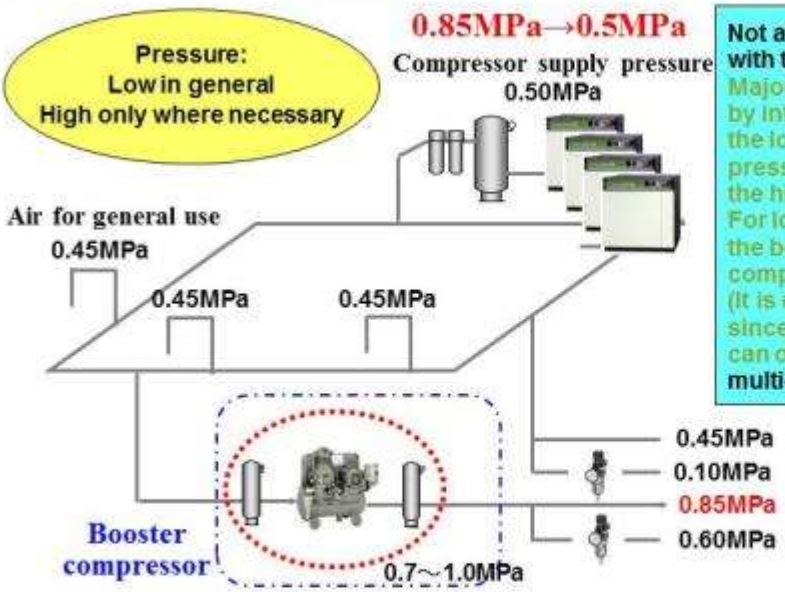
Why?
Incorrect understanding of power characteristics
Separate control

100kWINVERTER SCREW x 2 units (36.2 M³/min)





Efficient Usage··Example of Local High Pressurizing



Not all air used at factory is running with the same pressure.
Major energy saving can be expected by introducing low pressurizing for the low-pressure equipment and high pressurizing for the high-pressure equipment.
For local high-pressurizing, use of the boosting valve and the booster compressor is recommended.
(It is excellent in terms of energy since use of the booster compressor can obtain the same effect as the **multi-stage compressor)**

- Operation pressure of high pressure use section is 0.85MPa now using 37kW 3 compressors.
- Energy reduction of nearly 15% can be achieved if this operation pressure can be lowered up to
- 0.50MPa. In short, reduction of 37kW ÷ 0.9 x 2.5 units × 0.15 = 15.4kW can be achieved.
- Also, the load factor of the power for booster is set at 50% by using booster at 7.5kW,
- 7.5kW ÷ 0.9 x 0.5 = 4.2kW
- Therefore, energy saving of 15.4 - 4.2 = 11.2kW can be achieved.
- Annual energy savings is 11.2kW × 8000h = 89,600kWh (Rs. 627,200)

Contents

Selection criteria

Type of compressor	Capacity (m^3/h)		Pressure (bar)	
	From	To	From	To
Roots blower single stage	100	30,000	0.1	1.0
Reciprocating				
- Single/two stage	100	12,000	0.8	12.0
- Multi stage	100	12,000	12.0	700.0
Screw				
- Single stage	100	2,400	0.8	13.0
- Two stage	100	2,200	0.8	24.0
Centrifugal	600	300,000	0.1	450.0

Source: : Compressed air system, Bureau of Energy Efficiency, India

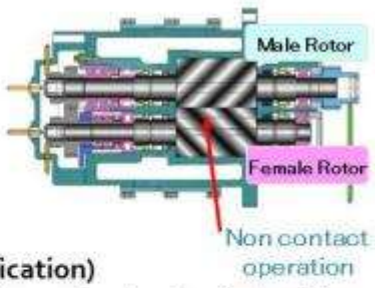
How to select air compressor

Cost	Small	Medium	Large
Payback period	Very short (less than half year)	Case by case	MAX. 4 years
Ease of implementation	Easy (Soft technology)	Slightly difficult (Hard + Soft technology)	Difficult (Hard + Soft technology)
Effect	Small ~ medium	Medium	1. Large
Items to be implemented	1. Reduce air pressure 2. Stop supply for not-in-use area 3. Repair leakage 4. Ventilate compressor room to cool down 5. Efficient air equipment blow gun, air cylinder, nozzle, joint, valves	1. Restructure piping system 2. Size up air-dryer and filter 3. Size up receiver tank 4. Use booster compressor 5. Divide pressure	1. Make clean air system oil-free system 2. Provide drive multi units with multi-controller system 3. Use VFD(VSD) compressor 4. Restructure compressor system choose large size or divide 5. Recover energy

- Compression Principle (Volumetric & Centrifugal)
- Lubricant & Sealing (Oil-flooded & Oil-free)
- No. of Compression Stages (Single Stage & 2 Stages)
- Cooling Methods (Air-cooled & Water-cooled)
- Number of units (Large size or divisible system)

Oil free air compressor

High skills and materials are necessary to manufacture.
Sealing is important even in high-speed operations.
Maintenance cost is higher than oil-flooded type.
Efficiency is slightly less than oil-flooded type.
Price is higher than oil-flooded type; in fact nearly double.



but

Oil-free compressor can get very clean air (class zero certification)
It can be used for high technology products and high quality use to develop industries for
Electronics, semi-conductors, food, medical supplies, textiles, and others
Oil-free air can meet HACCP, FSSC22000 and GMP regulations.

- HACCP; Hazard Analysis Critical Control Point
- ISO-22000 & FSSC22000; Foundation for Food Safety Certification
- GMP; Good Manufacturing Practice

Advanced technologies below are put into the compressors.

- Reciprocating compressor
- Screw compressor
- Scroll compressor
- Centrifugal compressor

Contents

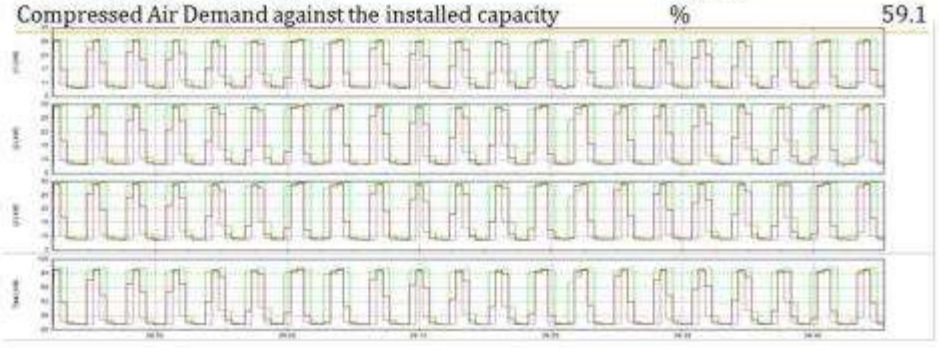
Select case study: Replacement of existing air compressors with inverter type (VFD) air compressor

Parameters	Unit	Reciprocating compressors				
		RC-3	RC-11	RC-12	RC-13	RC-14
Rated Capacity	m^3/min	13.75	13.75	28.33	28.33	28.33
Actual FAD	m^3/min	5.99	7.11	10.45	4.44	7.20
Actual air supplied by each unit	m^3/min	5.8	6.4	10.7	7.0	5.1
Motor rated capacity	kW	90	90	165	165	165
Average power consumption (demand test)	kWh	80.2	75.3	93.79	125.6	73
Specific power consumption (based on FAD)	kW/m^3/min	13.9	11.7	8.8	18.0	14.3
Weighted average of SPC	kW/m^3/min					12.8

- Average specific power consumption of compressed air system was 12.8 kW per cubic meter per minutes @ 5.5 bar against design of 6.5 kW/m^3/min
- Reason for poor efficiency: ***Age and poor maintenance (cooling system)***
- Installation of screw compressor with VFD shown the saving in energy up to 49% with a simple payback period of 18 months

Select case study: use of inverter type (VFD) air compressor in over capacity system

Particulars	Unit	Value
Total Installed Capacity	m^3/min	12.8
Actual Free Air Delivery (FAD)	m^3/min	12.7
Average load time of compressor in Business As Usual Scenario	sec	104
Average un-load time of compressor in Business As Usual Scenario	sec	80
Percentage loading of the compressor	%	56.5
Actual Air supplied to the plant	m^3/min	7.2
Compressed Air Demand against the installed capacity	%	59.1



Contents

IE cord regulation

IE (“International Energy-efficiency Class)

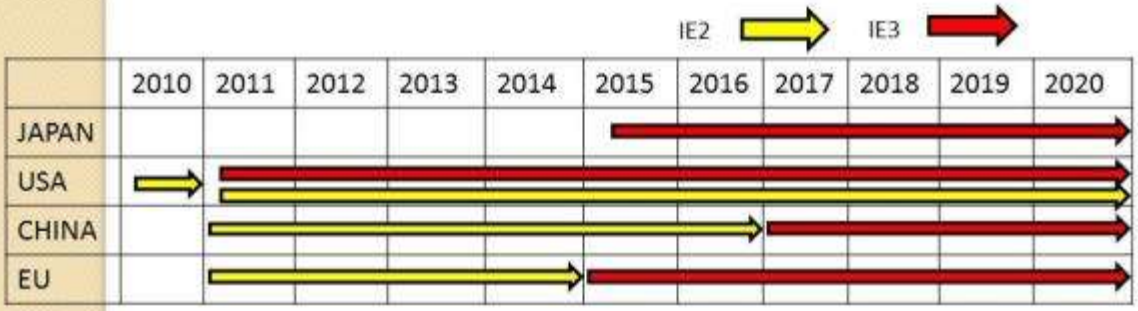
IE5	Super premium	IEC60034-30-1 (Annex)
IE4	Super premium	IEC60034-30-1
IE3	Premium	IEC60034-30-1(JIS C 4213)
IE2	High efficiency	JIS C4212
IE1	Standard class	JIS C4210

HITACHI IE5 MOTOR

HITACHI IE3 MOTOR

■ IE3 regulation

In japan using high class motor productive JIS C4212, it is IE2 level motor until March 2015. From April 2015 Up to 0.75～375kW (less than 1000V) motor IE cord up one class to reduce CO_2.

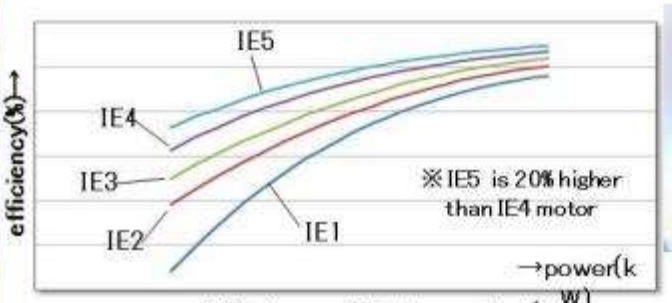


State of Overseas Regulations and International Standards

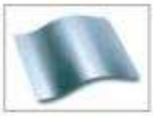
- Efficiency regulations for lone motors are promoted overseas.
- The efficiency standard IEC60034-30 was instituted in October, 2008.

IE1: JIS C 4210 equivalent, IE2: JIS C 4212 equivalent, IE3: started from April 2015

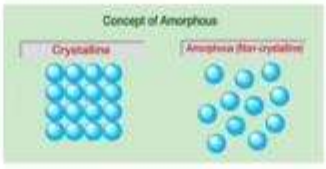
IE5 motor is made by amorphous metal



Efficiency of IE class motor (50Hz)



Amorphous metal



Amorphous transformer

Iron loss is 1/10 and the material by which loss has substantially compared with the flat rolled magnetic steel sheets and strip used for a conventional motor for amorphous metal.
For super energy saving series, amorphous metal is used as iron core for transformer.

Thank you

Industrial Energy Efficiency Division
The Energy and Resources Institute (TERI)
Darbari Seth Block, IHC Complex,
Lodhi Road, New Delhi 110003
Ph: +91 11 2468 2100 or 2111
Fax: +91 11 2468 2144 or 2145
E-mail: chetankumar.sangole@teri.res.in
URL: http://www.teriin.org

Institute for Global Environmental Strategies (IGES) Kansai Research Centre
Disaster Reduction and Human Renovation Institution, East Building 5F, 1-5-2, wakihama Kaigan Dori, Chuo-ku, Kobe, Hyogo, JAPAN
Tel: +81-78-262-6634
Fax: +81-78-262-6635
E-mail: abdessalem@iges.or.jp
URL: http://www.iges.or.jp

Annexure 4: Selected photographs of the event