

Industrial Energy Efficiency And The Road Towards A Low-Carbon Economy

While Singapore's industrial sector is a key economic growth engine, it accounts for a significant amount of greenhouse gas (GHG) emissions. Improving energy efficiency in the sector is a key strategy towards a low-carbon economy and helping businesses manage rising costs.



Singapore's commitment and effort to reduce emissions

Since independence, Singapore has pursued sustainable development by balancing economic growth with environmental protection and social inclusion.

Singapore enhanced its 2030 Nationally Determined Contributions under the Paris Agreement and

committed to peak its GHG emissions at 65 MtCO₂ equivalent around 2030. Subsequently, it announced a Long-Term Low-Emissions Development Strategy (LEDS) to halve GHG emissions to 33 MtCO₂ equivalent by 2050 with a view to achieve net-zero emissions by or around mid-century. This is to be achieved through 3 broad thrusts consisting of Energy Efficiency (EE), system-level solutions, and low-carbon technologies.

This article will focus on the effort in improving Industrial Energy Efficiency (IEE) to reduce the need for primary

energy, therefore reducing emissions while increasing energy resilience. Businesses can also benefit from the reduced operating costs, thereby enhancing long-term business competitiveness.

In 2019, the industrial-related sector accounted for 56.8% of Singapore's total emissions, with 41.5% as primary emissions and another 15.3% as secondary emissions.

Singapore promotes the continual improvement in IEE through a 3-pronged approach:

- Regulations and standards such as the Energy Conservation Act (ECA) and EE standards;
- Incentives for EE opportunities and assessment; and
- Capability building through professional development.

The role of the ECA

Several challenges had hindered the improvement of Singapore's IEE, such as the lack of awareness of EE improvement potentials, heterogenous and complex processes which differ between companies leading to a lack of benchmarks, and EE being secondary compared to other operational considerations such as reliability and production yield.

To address these challenges, the ECA, enacted in 2012, prescribes basic energy management practices for energy intensive companies. The requirements include appointing an energy manager, monitoring and reporting on energy use and GHG emissions, and submitting EE improvement plans.

The ECA covers energy-intensive companies in the industrial sector that consume at least 54TJ of energy per year, equivalent to 15GWh per year. They account for 80% of industrial energy consumption.

Enhancements to the ECA

Since the implementation of the ECA, several key challenges to IEE improvement were identified. Firstly, many common industrial equipment and systems performed at sub-optimal levels, and companies preferred like-for-like replacements instead of re-evaluating their operating conditions and using more efficient equipment. Secondly, existing facilities had limited opportunities to improve EE and reap synergies in system design during operation phase. Existing infrastructural constraints also made metering efforts challenging. Finally, there was a lack of a structured framework to manage energy use and sustain EE efforts, as they were seen as one-time efforts. Therefore, the ECA was further enhanced in 2017 to address these

energy management practice gaps.

To phase out inefficient technologies and catalyse market transformation towards more energy efficient ones, the Minimum Energy Performance Standards (MEPS) were introduced to set prescribed minimum EE levels. To help industrial companies benefit from life-cycle cost savings and mitigate sub-optimal operating efficiencies of common equipment and systems, MEPS were extended to industrial and commercial equipment, beginning with motors in October 2018 and continuing with lighting ballasts in August 2019 to Variable Refrigerant Flow (VRF) air-conditioners in April 2021.

Similarly, the Minimum Energy Efficiency Standards (MEES) for water-cooled chilled water systems were introduced with the intent of extending MEPS from equipment to multi-component systems. Unlike MEPS, which is enforced on equipment suppliers, MEES is regulated on end-users to ensure that companies not only purchase efficient system components, but also operate their systems at optimal efficiencies through system integration and optimisation, to reap higher energy savings.

To capture EE related system design synergies in the early design process and improve monitoring of facility energy use for effective energy management, the Energy Efficiency Opportunities Assessment (EEOA) and Energy Performance Measurement requirements were introduced for New Ventures (i.e., new business activities or major expansions of existing business activities under ECA). These New Ventures are required to conduct a review of their facility at the design stage to identify economically viable EE opportunities to incorporate into the facility's design, and plan for and install instrumentations to measure energy performances of their energy consuming systems.

Finally, to provide a structured framework for managing energy use, companies regulated under ECA are required to implement an Energy Management System (EnMS), modelled after the ISO 50001 by 2021 or 2022, depending on their facility's energy consumption. The EnMS operates on a sustained "plan-do-check-act" structure, which imposes a systematic approach on managing energy use through continual reviews on energy management efforts so that the intended outcomes are achieved.

In addition, EEOA for Registered Corporations was introduced for existing facilities regulated under ECA to conduct holistic energy assessments regularly (minimally once every six years). The energy assessments provide reliable energy, economic and technical information such that feasible and cost-effective recommendations for EE improvements

with measurable results can be developed. To ensure good quality assessments are conducted, these energy assessments need to be endorsed by certified EEOA assessors. As power generation companies ("gencos") regulated under ECA feedback that there were limited opportunities for power generation plants to uncover EE opportunities through typical energy assessments, they would be required to implement Energy Performance Monitoring (EPM) instead. EPM involves the development of a thermodynamic model of the power generation plant, allowing for performance benchmarks to be established under varying operating conditions. Through performance benchmarks, gencos can systematically monitor, evaluate, and identify areas of performance degradation so that targeted actions can be taken to recover efficiency losses.

Energy Efficiency Technology Centre

As a further step to encourage energy assessments, the Energy Efficiency Technology Centre (EETC) was established in 2020 as a collaboration between NEA and the Singapore Institute of Technology (SIT). The EETC aims to support capability building needs in the local EE ecosystem by (a) catalysing EE improvement at Small Medium Enterprises (SMEs) through provision of energy consultancy services; (b) training a pipeline of engineering students in industrial EE; and (c) upskilling existing engineers or EE practitioners.

The EETC offers industrial SMEs affordable professional grade energy assessments, consisting of in-depth diagnostics and analysis of energy processes, helping them establish their energy profile and allowing them to make informed decisions on EE improving investments. The EETC also aims to provide SMEs access to support and knowledge on their energy consuming systems, by imparting relevant skills to SME staff during the energy assessments. This will allow them to continue monitoring their own systems post-assessment.

The EETC also conducts training and upskilling programmes. Student training programmes provide practical trainings through attachments to the EETC or an industrial facility. EETC professional officers guide undergraduate students during energy assessments, including detailed metering, baseline and target energy performance, identification of improvement opportunities, implementation, and investment plan. These practical skills improve the students' employability in EE and ensure a pipeline of talents for the local EE ecosystem. For existing EE practitioners or engineers, the Energy Efficiency Upskilling Programme (EEUP) is a specialised training programme focused on major industrial systems such as compressed air systems, boilers, steam systems and electrical power systems. It consists of classroom sharing by experienced

instructors on key principles and theories, as well as authentic energy audits and assessments of industrial systems.

Energy Efficiency Fund

To help companies improve EE, the Energy Efficiency Fund (E2F) was launched in April 2017. The E2F supports various EE and low carbon initiatives, such as investing in energy efficient equipment or technologies, energy management information systems, water-cooled chillers using low-global warming potential refrigerant, energy assessments and resource efficient design of new facilities. The grants awarded to projects will vary, based on the carbon abatement achieved. Projects that achieve To help companies improve EE, the Energy Efficiency Fund (E2F) was launched in April 2017. The E2F supports various EE and low carbon initiatives, such as investing in energy efficient equipment or technologies, energy management information systems, water-cooled chillers using low-global warming potential refrigerant, energy assessments and resource efficient design of new facilities. The grants awarded to projects will vary, based on the carbon abatement achieved. Projects that achieve higher carbon abatement will be eligible for higher grant support.

From 1 April 2022, the E2F grant support cap for adoption of energy efficient technologies has been raised from 50 per cent to 70 per cent of qualifying costs per project. The E2F grant application and disbursement processes have also been simplified, which helps companies save time and cost.

As of June 2022, the E2F has supported more than 30 energy efficient technologies projects. These include retrofits of LED lighting, variable speed air compressors, high efficiency air-conditioning systems, and boiler systems. These projects have achieved an estimated annual carbon abatement of around 1,600 tonnes, which is equivalent to taking about 500 cars off the road.

Containers Printers Pte Ltd, a local SME that manufactures tin cans, plastic containers and printing of tin plates, has tapped on E2F to install high efficiency variable speed air compressor and low energy LED lighting. With the retrofits, they abated about 330 tonnes of carbon annually and enjoyed cost savings of more than S\$100,000 annually.

Kawarin Enterprise Pte Ltd, a local steel manufacturing company, has also benefitted from E2F. By upgrading their old air compressors to more energy efficient ones, they enjoyed annual cost savings of more than S\$30,000, and abated about 48 tonnes of carbon annually.

The industry is encouraged to take advantage of this higher support and invest early in energy efficient technologies which would lower their expenditures on energy in the current environment of rising energy prices and better position their businesses to cope with environmental sustainability.



Containers Printers' compressed air system.



Kawarin Enterprise's compressed air system.

Energy Efficiency National Partnership programme

Finally, to sustain IEE improvements, NEA recognised the need for capability building to create an eco-system that supports knowledge building and high-quality energy services.

To provide support to companies in their EE efforts through network activities and the provision of EE-related resources and recognition, NEA launched the Energy Efficiency National Partnership (EENP) programme on 29 April 2010. As of June 2022, there were 335 EENP companies. As an industry-focused voluntary partnership programme, partners commit to work towards adopting in-house EnMS at the organisational level to continuously and systematically measure and manage energy consumption, and identify EE improvements. This involves appointing an energy manager, developing an energy policy, establishing energy targets, and implementing EE improvement plans.

EENP partners can tap on the EENP Learning Network activities and resources to learn about EE ideas, technologies, best practices, and standards. Outstanding EENP partners are recognised for their efforts and achievements in improving EE through the biennial EENP Awards.

Conclusion

A sustained approach to improve IEE is required for Singapore to achieve its commitment to support multilateral efforts to combat climate change. Since the introduction of ECA, EE improvement rates in the industry have risen from 0.41% in 2014 to an average of 0.80% between 2014 to 2020.