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Mainstreaming Efficient Industrial Separation Systems

By
Alain Legault, Natural Resources Canada
Ricardo Rivero, Instituto Mexicano del Petróleo; Universidad Nacional Autónoma de México[2]

Separation of materials or phases has been an integral part of human life ever since primitive man discovered fire as a source of energy. In numerous different ways, separation techniques have played a central role in mankind's development, not least in production of food, clothing or tools. Today, output of power and a multitude of consumer goods all rely heavily on separation processes. As the drive for energy savings and sustainability intensifies, maximum efficiency becomes increasingly crucial.

Separation systems can represent between 40% and 70% of both capital and operating costs in industry. These systems account for 45% of all process energy used in the chemicals and petroleum-refining industries, where they are at the heart of operations, as they are in agro-food and many other materials-processing industries.

More efficient separation technologies and systems are critical factors for industries' long-term sustainability; they reduce waste and greenhouse gas emissions, improve energy efficiency and increase throughput.

It was these important considerations that led the IEA IETS programme to add a "Separation Systems" Annex to its portfolio of projects. As its full name implies, this Annex IX on "Energy Efficient Separations Systems: Methodological Aspects, Demonstration and Economics" aims to promote a mode of investigation where the focus is not limited to deep understanding of individual physical phenomena, but covers broad understanding of how complex, multi-phenomena, multi-scale separation systems are constituted, how they behave and how their components interact and interrelate. The IETS Separation Systems Annex is concerned with processes that use one or more forms of energy – thermal, chemical or electrical – to isolate and/or re-combine selected constituents from an initial ensemble of materials or mixtures, and so produce a useful, improved end-product with an acceptable environmental footprint. More precisely it is concerned with the "systems" aspects of these separation activities.

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[1] The IEA ***OPEN Energy Technology Bulletin*** is a web-based periodical newsletter published by the International Energy Agency (**IEA**).

[2] Dr Alain Legault of Natural Resources Canada and Professor Ricardo Rivero of Mexico's Instituto Mexicano del Petróleo (IMP) and Universidad Nacional Autónoma de México (UNAM) are Annex Managers of Annex IX on Energy Efficient Separations Systems: Methodological Aspects, Demonstration and Economics, which is a part of IEA Industrial Energy-Related Technologies and Systems (IETS). The IETS Implementing Agreement programme is one of the IEA's international energy technology **collaborations**.

In terms of both technology and application, industrial separation technologies cover a vast field. Across different industrial sectors, techniques like distillation, adsorption, crystallization, membrane use or extraction are applied in a wide spectrum of ways.

Broadly speaking, however, separation systems can be considered as performing similar functions in all industries, so that R&D potentially capable of expanding the fundamental knowledge needed to improve existing separation systems and to develop new systems can have a very large impact on sustainability in many different industrial sectors.

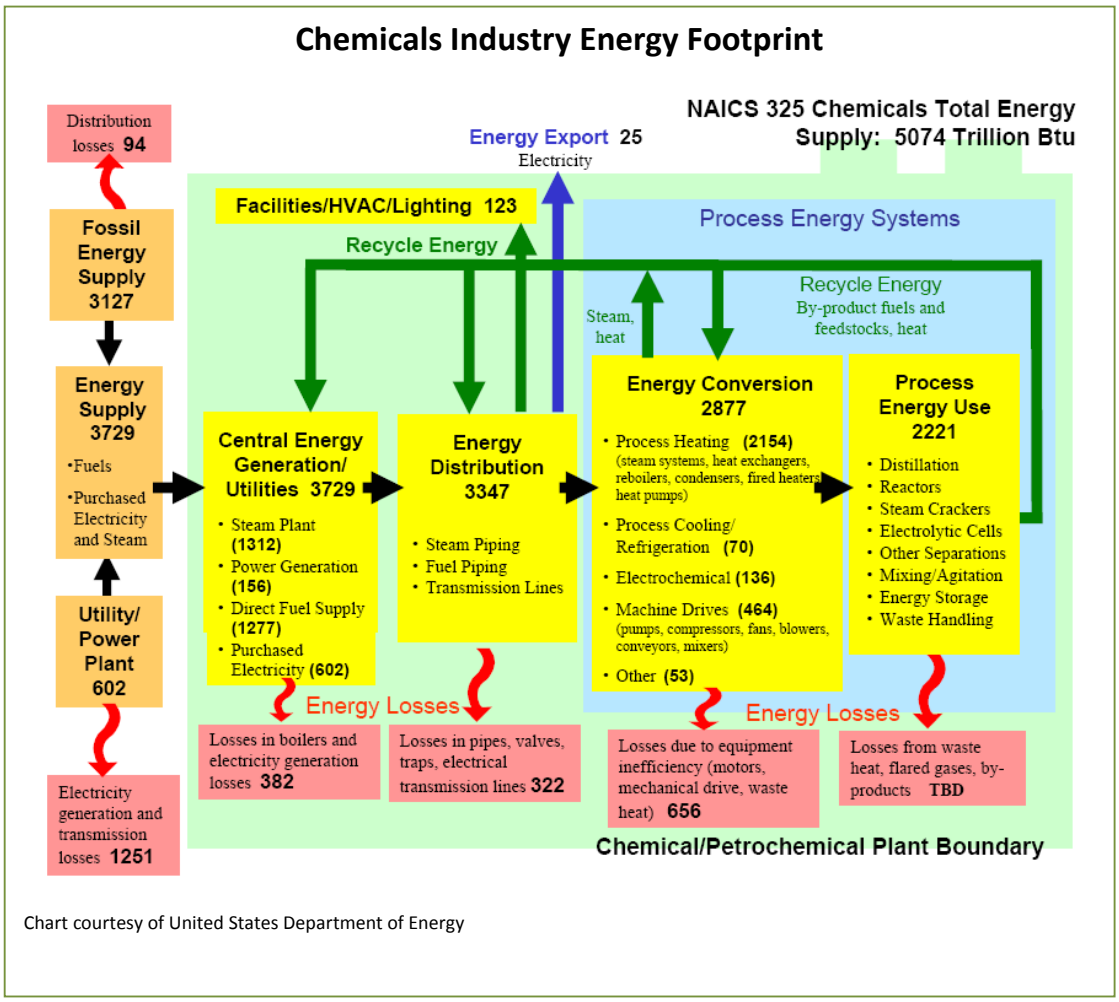

Chart courtesy of United States Department of Energy

To appreciate the importance of separation operations in one strategic industrial sector, the above very instructive chart from the United States Department of Energy illustrates footprint analysis of energy use in the chemicals industry.[3]

[3] United States Department of Energy Industrial Energy Program, Energy Use and Loss Footprints, http://www.eere.energy.gov/industry/energy_systems/footprints.html

As we can see, the total energy delivered to chemical plants in the United States is 3729 trillion BTU (after energy losses). But only 77% makes its way to the process area (2877 trillion BTU). Of that portion, the percentage of energy actually delivered to the processes is again 77%. These processes – which are predominantly separation operations – therefore use only 60% of the total energy delivered to the industrial plants.

IEA Industrial Energy-related Technology and Systems (IETS)

IETS addresses energy use in a broad range of industrial sectors. It plays a central role in IEA industry-related activities.

IETS was established in 2005 to consolidate IEA's existing or planned collaborative energy technology activities in the fields of pulp & paper, process integration, heat exchangers & heat transfer, and separation technologies. It is evolving as new activities are initiated.

The objective of IETS is to enable countries – whether IEA members or not – to work together to foster international co-operation for accelerated research and technology development of industrial energy-related technologies and systems. Its main focus is on end-use technologies.

The **IETS programme** brings together 12 countries: Brazil, Belgium, Canada, Denmark, Finland, Korea, Mexico, the Netherlands, Norway, Portugal, Sweden and the United States.

While actual losses at the process stage of energy use are not detailed in this analysis, it is clear that improvements in the energy efficiency or throughput of these operations will have a major impact on this industrial sector's overall efficiency. The analysis can be repeated, with similar conclusions, for other sectors where separation operations are important, such as food and beverages, petroleum refining or textiles.

What contribution is the IETS Separation Annex making to tackling such clearly unsatisfactory levels of energy optimisation? To start with, the parties involved are working to ensure that recent developments in energy-efficient separation technology and analysis are actually implemented. They are developing methods and tools to identify separation processes where heat-integrated distillation columns (HIDICs) and hybrid separations may be used advantageously. Crucially, project participants are using the IETS Annex IX as a forum for sharing information on current research projects and on best industrial practices. Annex participants also plan to develop a joint R&D plan for developing various technologies, including next-generation HIDICs and hybrid separations.

One of the Annex IX subtasks is making a preliminary selection of interesting technologies for focus. The ongoing level of interaction the Annex establishes with the industrial sector will depend on well chosen fields of technology, bearing in mind that well established industrial applications optimised in the field through years of testing and development may already be operating very close to the achievable thermodynamic "optimum". A first set of technologies identifies those where industrial partners' design procedures already focus on energy efficiency and where the prospects of further energy savings to reduce corporate operating costs and enhance environmental profile are attractive. At this stage, the following areas have been selected.

- Hybrid distillation columns (column+membranes, column+pressure swing adsorption [PSA], etc)
- Heat-integrated distillation columns (HIDICs)
- Gas clean-up technologies (absorption/stripping, triethylene glycol - monoethylene glycol [TEG-MEG])
- Power production with CO_2 capture.

Since 2007, Annex IX participants have been working to promote effective, practical design or retrofit of separations systems. While numerous modeling tools and methodologies are available to the design engineer and scientist today, these sometimes tend to introduce layers of mathematical/technical detail that can detract from the original purpose of the exploration. It is intended that, by the end of the project period, an optimal combination will be defined of the physical/mathematical/engineering concepts that can best guide the search for a separation system to meet a given set of requirements.

The IETS Annex IX team welcomes new participants.

As its managers, we should be pleased to provide any further information readers require.

Dr. Alain Legault
Natural Resources Canada
alain.legault@nrcan.gc.ca

Prof. Ricardo Rivero
Instituto Mexicano del Petróleo (IMP) and
Universidad Nacional Autónoma de México (UNAM)
rrivero@imp.c0m