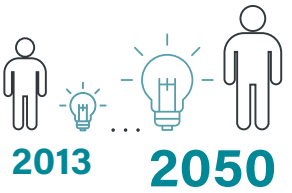
The International Bromine Council

www.bsef.org

Bromine and Energy Storage

ENERGY STORAGE
A KEY ENABLER FOR LOW CARBON ENERGY SYSTEMS



With the global population expected to grow by two billion people to reach 9.7 billion by 2050, the World Energy Council is predicting an almost twofold increase in global energy demand over the period[1].

The 2015 Paris Climate Agreement saw the global community commit to avoiding global temperature increases by reducing greenhouse gas emissions. On its way to decarbonisation, and to be able to meet growing demand, the electricity sector is undergoing a major transformation as economies and consumers move away from fossil-energy-based power systems towards climate-friendly systems with an increased production and use of renewable energy.

As the supply of renewable energy grows, energy storage becomes more important. The production of electricity from wind and solar can vary significantly throughout the day. As a result, electricity is not always consumed at the time it is produced.

By storing, we can use clean electricity when we need it. Energy storage will play a key role in enabling economies globally to accelerate the energy transition. Currently there is limited storage of electricity in global electricity systems.

On average only 30 minutes of electrical energy storage is available compared to 30 days for oil[2].

Demand for energy storage is therefore expected to increase as the supply of renewable energy grows. By expanding energy storage capacity, we will be able to fully exploit the growing capacities of renewable energy for a range of energy service applications from grid balancing to facility energy management.

1 Source: Worl Energy Council, 2013 - World Energy Scenarios: Composing energy futures to 2050
2 YouTube: ICL's innovative bromine based technology for energy storage

RENEWABLE ENERGY
USE IT OR LOSE IT - UNLESS YOU STORE IT

Since the mid-2000s the EU has been proactively diversifying its energy mix with a strong focus on renewable energy. In 2015 the total share of renewable energy in final energy consumption in the EU was 15.3%, up from 8.7% in 2005[3].

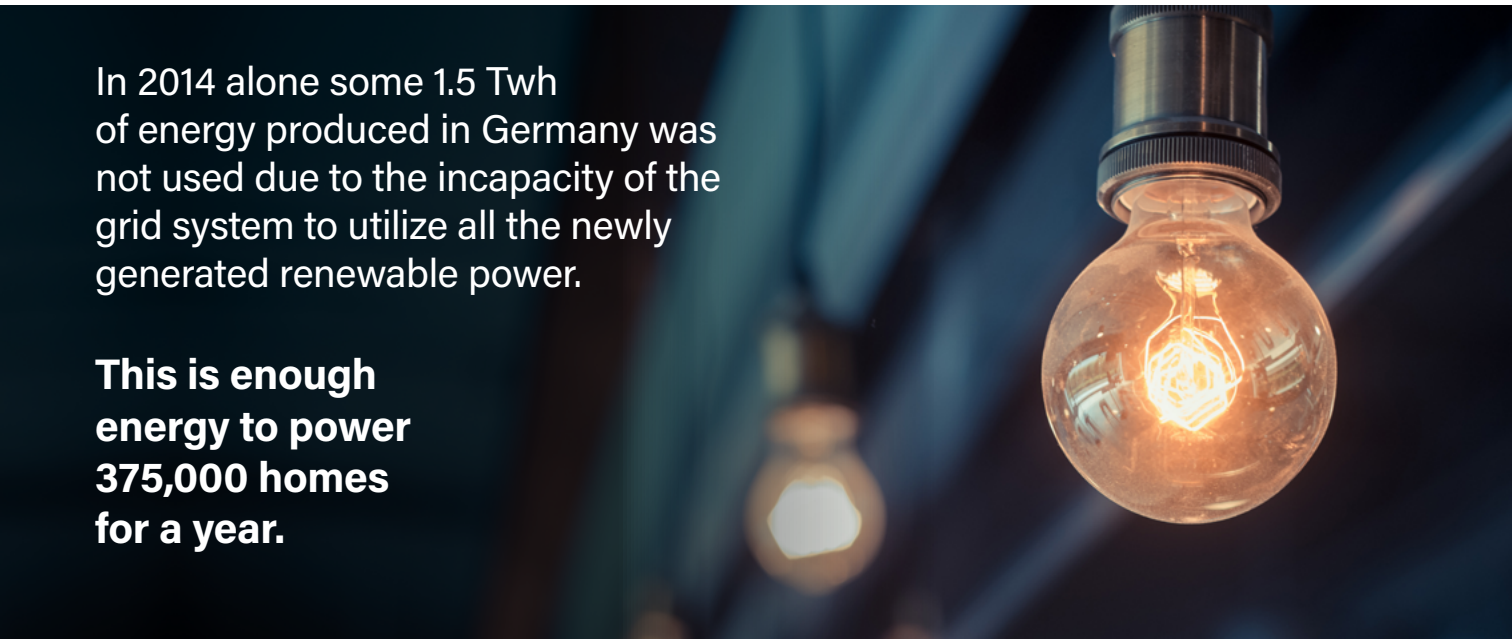
The increase in renewable power raises new challenges to the European grid systems. The current grid capacity is strained or even insufficient to cope with the growing volumes of renewable power, as well as the increasing demand from industry and consumers for more renewable power.

Renewable energy also tends to be variable and intermittent, which can make it difficult to maintain a continuous supply to the grid. In times of low demand and high renewable electricity production wind turbines or solar panels are "switched off".

This is what is called curtailment and represents a missed opportunity to generate more clean energy.

The case for expansion of energy storage is therefore key to efficient and sustainable management of low-carbon, renewable energy resources.

3 Source: Eurostat



ENERGY STORAGE TECHNOLOGIES

Energy storage allows electrical systems to utilize renewable energy without the need for a continuous connection to the grid. Locally, it can improve the management of distribution networks, reducing costs and improving efficiency. It can also give customers freedom to manage their own power needs.

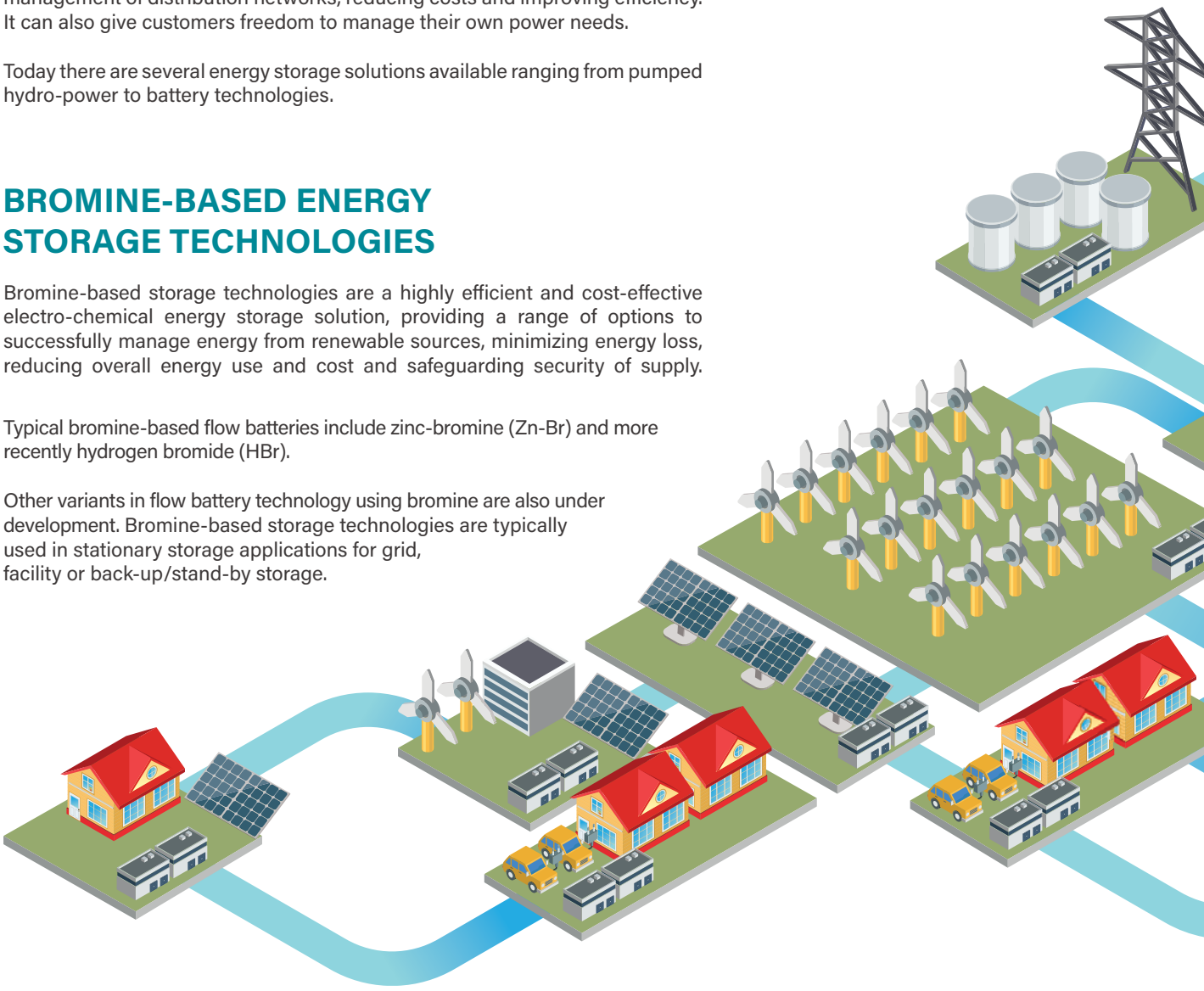
Today there are several energy storage solutions available ranging from pumped hydro-power to battery technologies.

BROMINE-BASED ENERGY STORAGE TECHNOLOGIES

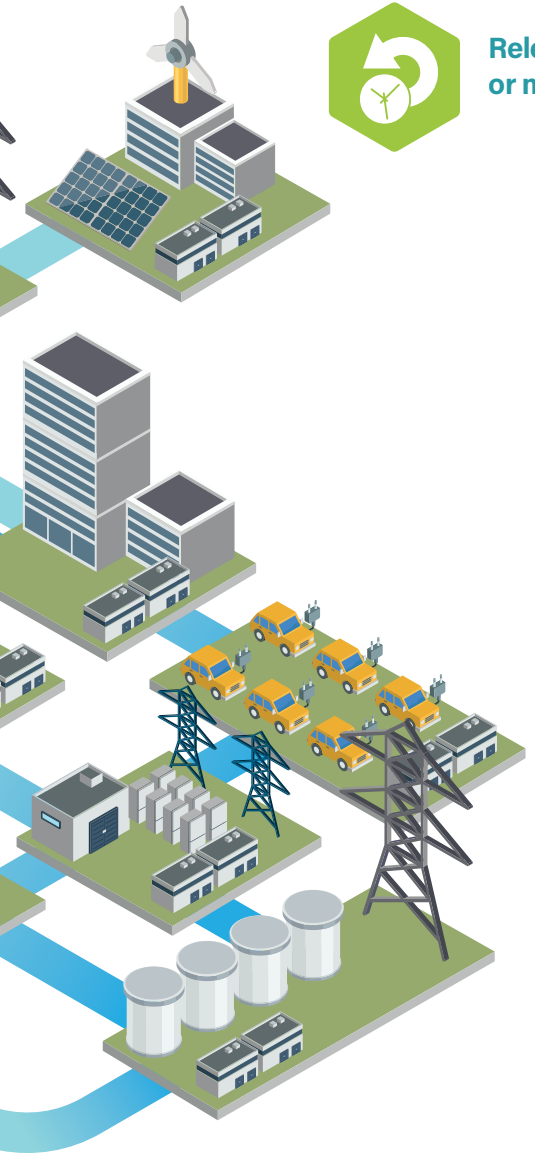
Bromine-based storage technologies are a highly efficient and cost-effective electro-chemical energy storage solution, providing a range of options to successfully manage energy from renewable sources, minimizing energy loss, reducing overall energy use and cost and safeguarding security of supply.

Typical bromine-based flow batteries include zinc-bromine (Zn-Br) and more recently hydrogen bromide (HBr).

Other variants in flow battery technology using bromine are also under development. Bromine-based storage technologies are typically used in stationary storage applications for grid, facility or back-up/stand-by storage.



THE ADVANTAGES OF BROMINE-BASED TECHNOLOGIES



Release energy continuously up to 10 hours or more at a high rate of discharge

Decouple power and energy
offering flexibility for applications
that require either high power or high energy

Recharge over 10,000 times

Increased storage capacity
of each single battery (high energy density)

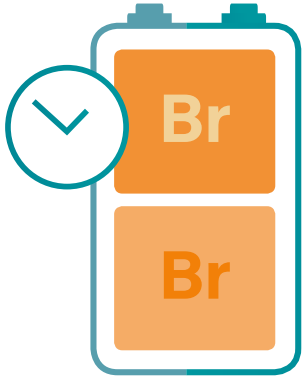
Recharge easily and quickly

Bromine-based storage technologies are being deployed more and more.

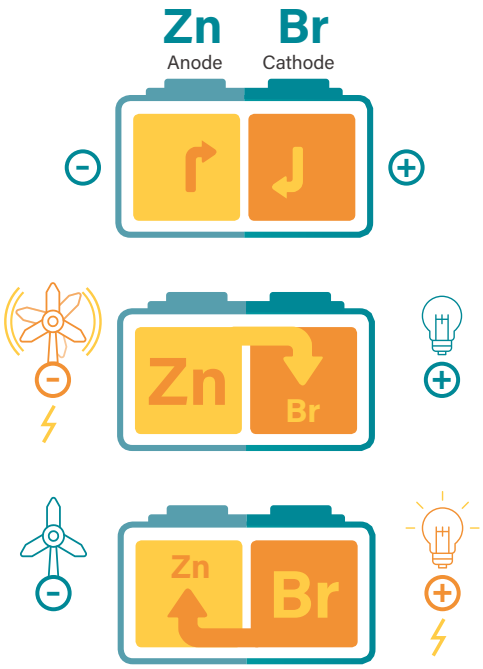
Today, there are some large sites around the world using Bromine flow batteries in order to help balancing energy deficiency. For example, the US Department of Defense uses zinc-bromine batteries for its military microgrid at the Marine Corps Air Station in Miramar California. The bromine-based technology, provided by Primus Power, was chosen for its extended duration, reliability and low cost after detailed and has helped to improve energy security, promote energy efficiency and reduce reliance on fossil fuels.

HOW DOES THE ZINC-BROMINE FLOW BATTERY WORK?

Typical bromine-based energy storage technologies are based on redox flow (after reduction–oxidation), principles. In effect, they are a rechargeable battery consisting of one or two tanks that contain chemicals dissolved in liquids and which are usually separated by a membrane. When the two solutions flow from one tank to the other, they generate a charge by moving electrons back and forth between the tanks, thus creating energy. A flow battery is technically similar to a fuel cell and an electrochemical accumulator cell (electrochemical reversibility).



Flow batteries can be recharged rapidly by replacing the electrolyte which is stored outside the cell. These rechargeable batteries can be left fully discharged indefinitely.

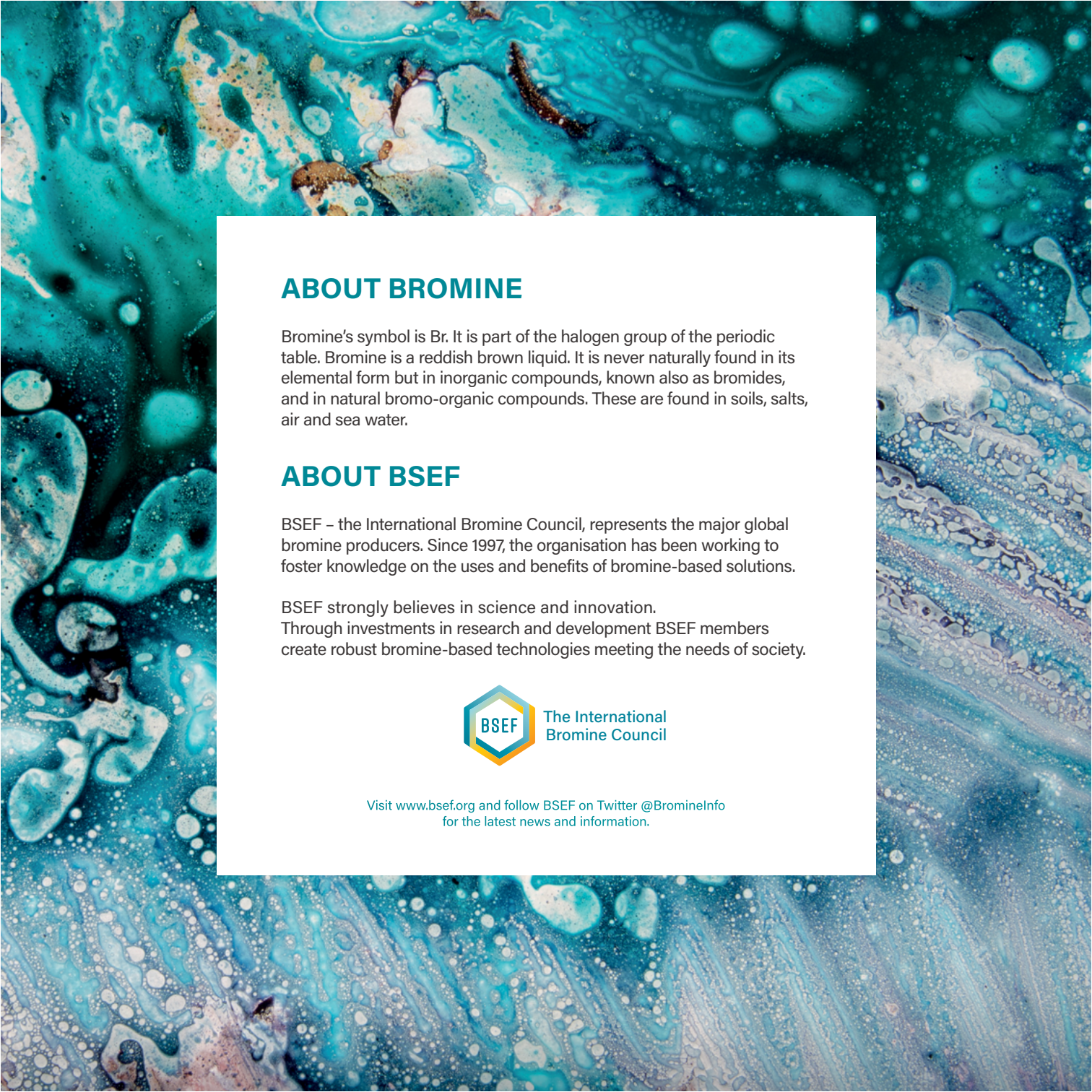


The zinc–bromine flow battery is a hybrid flow battery fuelled by the reaction between zinc and bromide.

The battery is composed of two compartments. A zinc anode and a bromine cathode, divided by a porous membrane and aqueous zinc bromide flows through them.

When electricity is stored, it reacts with the zinc bromide solution, forming bromine on the battery electrodes and electroplating the zinc.

When electricity is being used, the electro-chemical reaction between zinc and bromine is reversed. Electricity is produced and the zinc bromide solution is reformed.



ABOUT BROMINE

Bromine's symbol is Br. It is part of the halogen group of the periodic table. Bromine is a reddish brown liquid. It is never naturally found in its elemental form but in inorganic compounds, known also as bromides, and in natural bromo-organic compounds. These are found in soils, salts, air and sea water.

ABOUT BSEF

BSEF – the International Bromine Council, represents the major global bromine producers. Since 1997, the organisation has been working to foster knowledge on the uses and benefits of bromine-based solutions.

BSEF strongly believes in science and innovation.
Through investments in research and development BSEF members create robust bromine-based technologies meeting the needs of society.

BSEF The International Bromine Council

Visit www.bsef.org and follow BSEF on Twitter @BromineInfo for the latest news and information.

OUR MEMBERS

BSEF champions bromine's many benefits around the world. Bromine-based solutions are essential to many of the most important advancements in science and technology.

The members of BSEF are Albermarle Corporation, ICL Industrial Products, Lanxess and Tosoh Corporation.

LANXESS Energizing Chemistry

ALBEMARLE®

TOSOH

ICL Industrial Products Where needs take us

FOR FURTHER INFORMATION CONTACT US AT

The International Bromine Council

BSEF aisbl
Av. E. Van Nieuwenhuyse 4
1160 Brussels - Belgium

T: +32 2 792 7550
www.bsef.org

Follow us

@bromineinfo

@BSEF