



Dow Water & Process Solutions

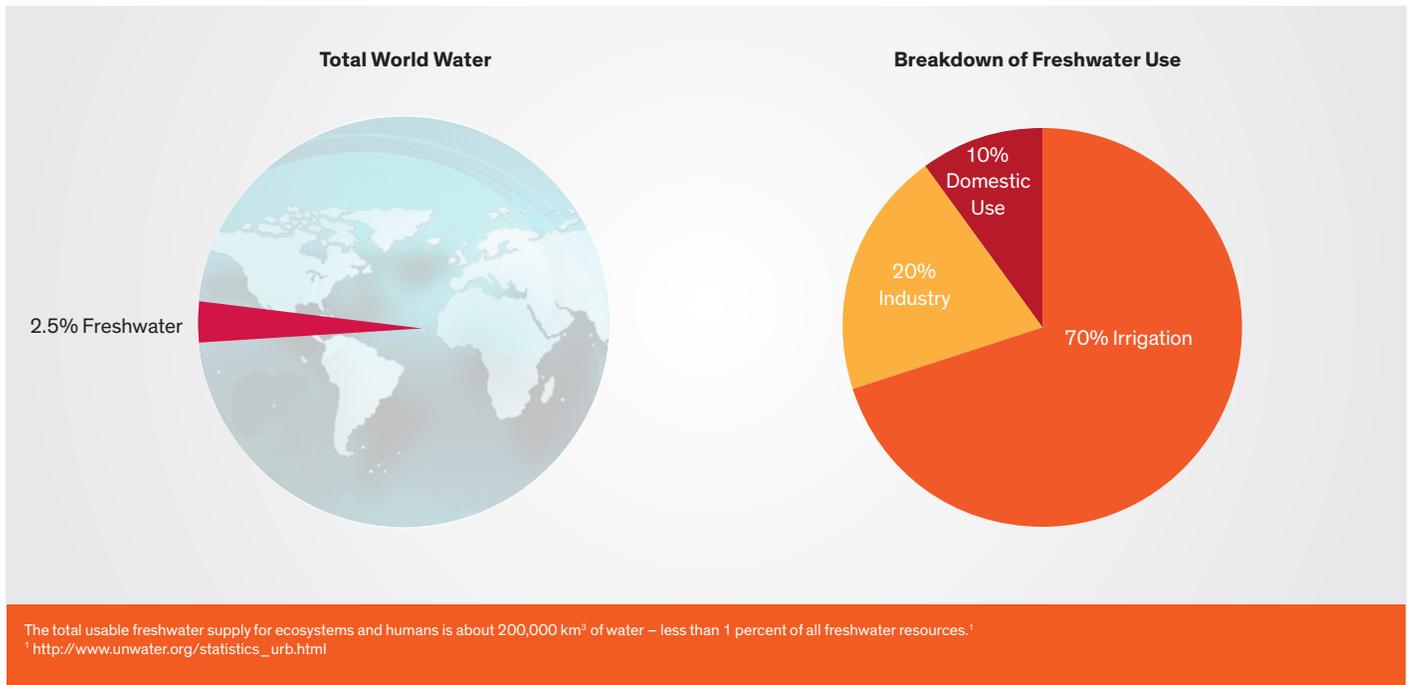
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## **Breakthrough to a World Challenge**

DOW FILMTEC™ ECO Reverse Osmosis Elements

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## I. Executive Summary

In every corner of the globe, from developing countries to industrialized nations, clean water is essential to sustain life. From providing hydration and nourishment, to lighting up our cities and manufacturing goods, water is the lifeblood of human progress.

In 2009, Davos World Economic Forum reported the world is quickly heading towards “water bankruptcy.” With the world population estimated to grow from 7 billion in 2011 to more than 9 billion by 2050, profound stress has been placed on the world’s limited water supply not only by its burgeoning population, but other issues, such as rapid urbanization, industrialization, pollution and climate change. Population growth leading to an increase in water requirements will also necessitate increased energy requirements, and water and energy are inseparable – water is required to make use of energy, and energy is required to make use of water. The lack of technology, poor management or inefficiencies in one area that can affect the sustainability of the other.

Water is also a vital commodity needed for energy-generation and commercial and industrial operations. As an integral element to the manufacturing process, water is used in every industry – from steel and paper to chemicals and energy to

textile and food products. It takes 10 liters of water to produce one sheet of paper, 91 liters to manufacture one pound of plastic, and 10,855 liters to make a single pair of jeans. Water cools and heats. It washes and scrubs. And it’s a key ingredient in the finished product. No factory can run – and no company can operate – without water.

Desalination and water reuse in industry has emerged as one of the most important themes in the water sector over the past five years. During the next five years, the technologies associated with salt removal and turning low-quality wastewater and raw water sources into high-quality process water will become an essential part of sustainable economic growth.

As a part of its 2015 Sustainability Goals, Dow is committed to developing breakthrough technologies to address pressing world challenges. After nearly 30 years of incremental change in Reverse Osmosis (RO) technology, Dow Water & Process Solutions has invented a new, breakthrough polymer chemistry, resulting in best-in-class performance from a new family of RO products. DOW FILMTEC™ ECO Reverse Osmosis Elements from Dow Water & Process Solutions are being used to produce freshwater, and recycle wastewater around the globe.

Compared to current best-in-class water purification membranes, FILMTEC™ ECO Membrane Modules filter out 40 percent more salt from water, while consuming 30 percent less energy than industry standard RO elements, resulting in an ecologic and economic win. New membrane chemistry allows for a new kind of water treatment plant to emerge – one that runs on less energy, operates more efficiently due to fouling resistance, and reduces environmental impact.

## II. Sustainability at Dow

By 2030, under an average economic growth scenario and without efficiency gains, global water requirements will grow from 4,500 billion cubic meters today to 6,999 billion cubic meters – a 50 percent increase in just two decades. Analysts predict that available water supplies will satisfy only 60 percent of demand, as population, urbanization and higher living standards continue to rise.

FILMTEC™ ECO REVERSE OSMOSIS ELEMENTS	
<b>PEOPLE</b>	Experts in RO Membranes for over 40 years, Dow scientists have engineered a new generation of membrane technology*
<b>PLANET</b>	Addressing the water-energy nexus with sustainable solutions provides ecological benefits for the entire value chain
<b>PERFORMANCE</b>	Superior membrane technology providing reduced energy usage, reduced chemical usage and 99.7% rejection

\*Patent Pending

Dow is committed to developing product innovations and game-changing technologies that help meet growing global demand for safe and available water resources across the globe.

Dow Water & Process Solutions has enabled greener energy production through advancements in desalination, water filtration, treatment and reuse, helping process over 15 million gallons of clean water a minute across the globe. By addressing the “three Ps” – people, planet and performance – Dow brings innovations to the market with deep technical expertise, global reach and a diverse product portfolio to help solve the world’s water problems in a more sustainable way.

## III. Dow's 2015 Sustainability Goals

Dow’s approach to sustainability is to set clear and challenging goals, measure rigorously and report regularly. This bold accountability inspires innovation in the company and builds respect among stakeholders and collaborators.

In 1995, Dow set important goals to improve our environment, health and safety performance and was recognized for its achievements. In 1996, Dow set the bar even higher, focusing its efforts on strengthening relationships within the communities where it operates, continuing to improve its product stewardship and innovation to solve some of the world’s most pressing challenges, and reducing its global footprint.

The 2015 Sustainability Goals drive the way Dow approaches business and sustainability by identifying ambitious, measurable benchmarks:

### Breakthroughs to World Challenges

Dow is actively working toward – and committed to achieving – at least three breakthroughs by 2015 that will significantly help solve world challenges in the following areas:

- Energy and Climate Change
- **Water**
- Food
- Housing
- Health

**Sustainable Chemistry.** By 2015, Dow will increase the percentage of sales to 10 percent for products that are highly advantaged by sustainable chemistry.

**Addressing Climate Change.** Dow will maintain all greenhouse gas emissions below 2006 levels.

**Energy Efficiency and Conservation.** Dow will reduce its energy intensity 25 percent by 2015.

<sup>2</sup>Naturally occurring water having a low concentration of total dissolved solids

<sup>3</sup>“Charting our Water Future: Economic Frameworks to inform Decision-Making,” 2030 Water Resources Group, 2009.

<sup>4</sup>“The business opportunity in water conservation,” The McKinsey Quarterly 2010 Number 1, pg. 68.

**Product Safety Leadership.** Dow will publish product safety assessments for all products by 2015.

**Contributing to Community Success.** By 2015, 100 percent of Dow sites where the company has a major presence will have achieved individual community acceptance ratings.

**Local Protection of Human Health and the Environment.** By 2015, Dow will achieve on average a 75 percent improvement of key indicators for EH&S operating excellence from 2005 baseline.

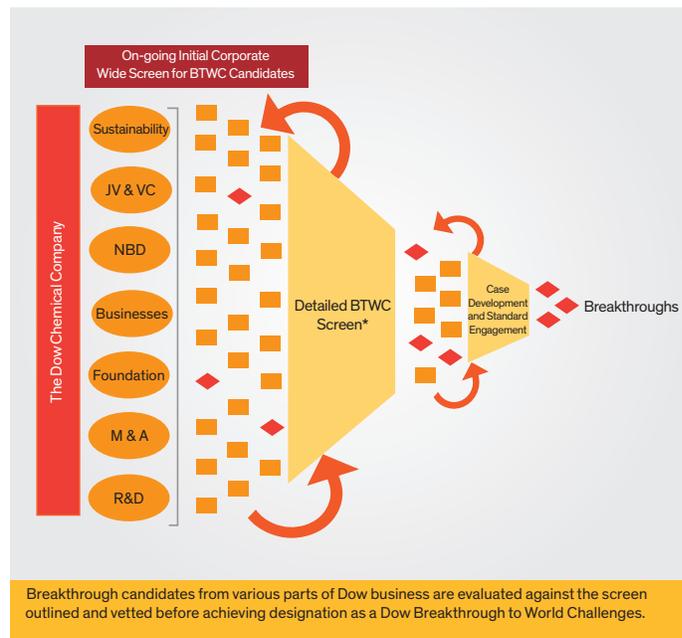
#### IV. Breakthroughs to World Challenge Goals

Dow is actively working toward and committed to achieving at least three breakthroughs by 2015 that make significant progress in the areas of energy and climate change solutions, sustainable water supplies, adequate food supply, decent and affordable housing, and personal health. A breakthrough is an innovation, whether in a technology or business model, that has the ability to scale to levels that will significantly impact the quality of lives around the world.

The Breakthroughs to World Challenges Goal (BTWC) identifies areas in which the company has unique competencies, and for which Dow employees have the passion and drive to make a contribution. The objectives of the BTWC Goal are simple: to address basic global needs and to create new sources of value for the company. Currently, Dow is sourcing innovation and breakthroughs by:

- Devising new technologies that improve products and services;
- Developing new business models and opportunities;
- Examining how to leverage existing technologies into new markets, emphasizing innovation; and
- Providing funding to start-up enterprises that bring needed solutions.

Breakthrough technologies include new, unique chemistry; a significant new manufacturing process for existing products; or new methods of delivery for existing products. The “challenge platforms” were chosen because of their connection to an existing Dow business and the increased likelihood for developing successful new or enhanced products and technologies that can help solve these critical world challenges.



In creating this goal, Dow was heavily influenced by the United Nation’s Millennium Development Goals (MDGs), which are focused on developing countries. Dow will also seek opportunities for addressing challenges in the developed world.

#### V. Criteria for Determining Breakthroughs

A breakthrough to a world challenge can take many forms. Given this variety, Dow established basic screens to evaluate innovations for their impact toward alleviating world challenges. This screen is made up of five key areas, each of which is considered when evaluating the impact of an innovation:

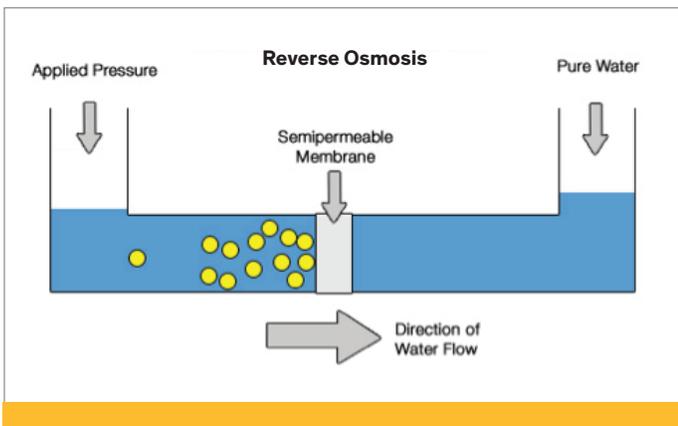
**Alignment** – The innovation aligns with one or more of the five key categories of world challenges: energy and climate change, water, food, housing and health.

**Significance** – The innovation makes a positive impact today or in the near future. Breakthroughs are intended to be implementable rather than theoretical, providing significant measurable impact. The measure of significance can vary depending on the type of innovation and the challenge addressed, but in all cases it must positively impact millions of human lives.

**Benefits** – The benefits of implementing the innovation significantly outweigh any potential challenges.

**Life Cycle View** – Each stage of the solution’s “life cycle” – from development through manufacturing, distribution, use and end-life – is carefully vetted in regards to raw materials, energy use, water use, hazard profile, disposal and other social and environmental considerations.

**Transparency** – The positives and negatives of the innovation are publicly disclosed and openly discussed with key stakeholders. Multiple aspects of the innovation are candidly and transparently evaluated.



## VI. Why the World Needs FILMTEC™ ECO Elements

The manufacturing industry has the opportunity to play a key role in helping manage water and energy resources. The industrial use of water is one of the largest uses of treated water. Industrial RO applications provide water for manufacturing, fabricating, processing, washing, steam generation and cooling, and for incorporating into the products themselves. Consequently, increasing water scarcity has driven companies to seek out both time-tested and new ways to purify water and promote water reuse that are both cost-effective and environmentally conscious.

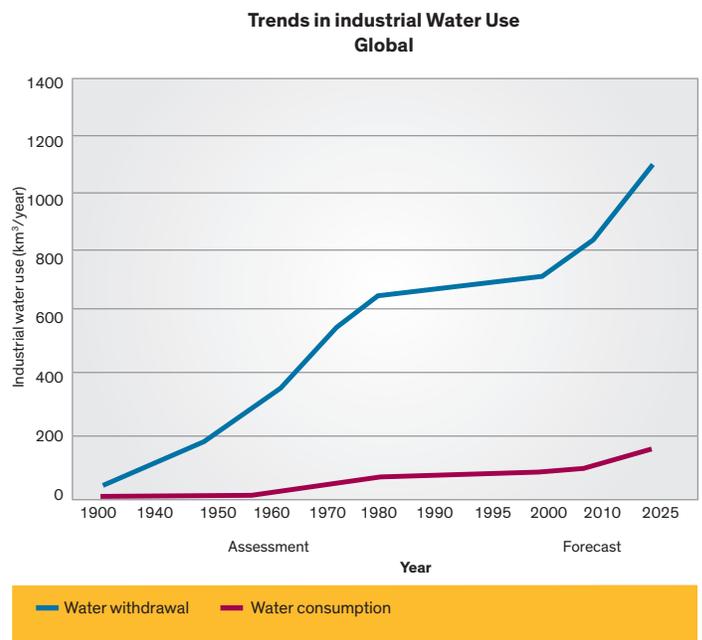
Conserving energy and water are primary goals for industrial manufacturers, as they look to produce high-quality goods in an efficient and cost-effective manner. Manufacturing sites require reliable water utility, matching the water quality specifications needed for their products, as well as chemicals to run their water purification systems. Sustainability is also a main factor in the water treatment decision-making process, as companies look to improve their energy consumption and lower their chemical usage. FILMTEC™ ECO Elements provide added ecological and economical value, as the product not only increases sustainability over time, but reduces energy and chemical costs.

## VII. Introduction to the reverse osmosis breakthrough

RO has a long and successful history in meeting the water quality and quantity challenge. By separating salt and other impurities from water at the molecular level, RO comprises the finest level of filtration available. The RO membrane is a nano-structured composite that is fabricated into commercially-viable modules, which are in turn the building block of modern RO systems.

Since the development of RO in the late 1950’s and early 1960’s, the scope for its application has been continually expanding. Initially, RO was applied to the desalination of seawater and brackish water. Increased demands on the industry to conserve water, reduce energy consumption, control pollution and reclaim useful materials from waste streams have made new applications economically attractive.

After nearly 30 years of incremental change in RO technology, predominately focused on improving existing membrane chemistry, Dow Water & Process Solutions has invented a new, breakthrough polymer chemistry, resulting in best-in-class performance from a new family of RO products. Dow scientists have reduced the energy required to purify water by focusing both on membrane innovation and the configurational aspects of module design. The building blocks of this new technology are an advanced, thin-film polyamide membrane chemistry and a new, low pressure-drop feed spacer configuration.



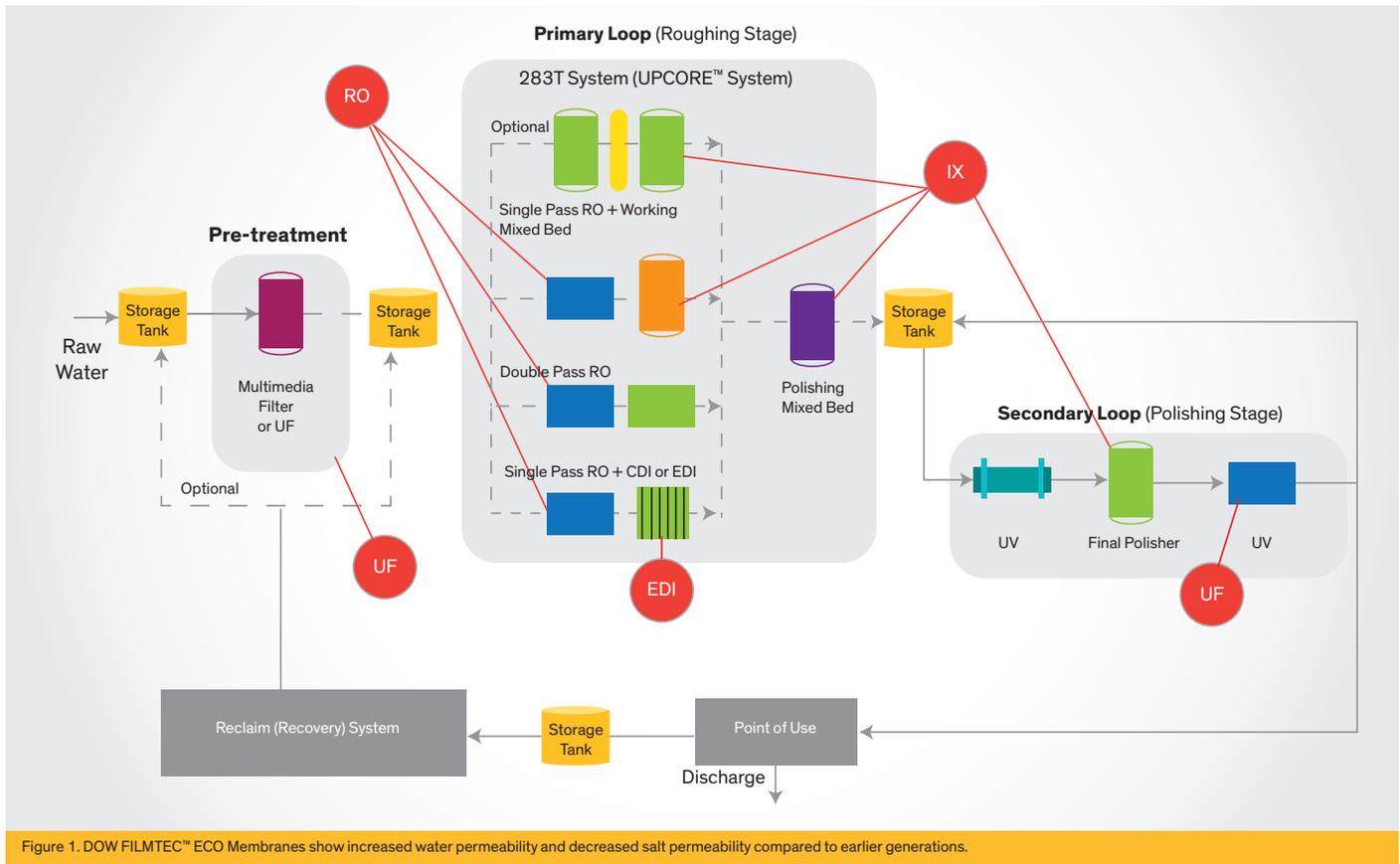


Figure 1. DOW FILMTEC™ ECO Membranes show increased water permeability and decreased salt permeability compared to earlier generations.

The membrane chemistry provides high salt rejection at lower pressures than previously possible, while the new feed spacer is variously deployed to provide either low membrane fouling, low pressure drop, or high packing density.

FILMTEC™ ECO RO Elements produce demineralized water from contaminated water sources, such as surface water, ground water, treated wastewater effluent, well water or tap water, and offer unparalleled solids rejection and flow performance for industrial water needs. RO membranes now offer the possibility of higher rejection of salts at significantly reduced operating pressures, and therefore, reduced costs. The innovation reduces energy consumption and ion exchange regeneration costs through improved hydraulic balance and lower feed pressure, resulting in operational savings between 16 and 19 percent.

### VIII. Breakthrough Criteria of FILMTEC™ ECO Elements

Whether to confirm individual components or the total product, FILMTEC™ ECO Elements have undergone rigorous testing to validate its performance across various conditions, including mechanical compression, tension and fatigue testing, torture testing, and long-term storage, among others. The new technology has been awarded more than 15 patents and is the first product in the portfolio family of more sustainable, higher-efficiency membranes. FILMTEC™ ECO Elements entered the market in 2012, a short 2-1/2 years after the initial discovery of the breakthrough polymer chemistry.

#### Significance and Impact

Globally, microfiltration membrane treatment is likely to witness 15 percent compound annual growth from 2008 to 2015, of which industrial wastewater applications are already on the rise. Increasing production volume and technological improvements have reduced capital cost of membrane systems and operating cost to the point that membrane treatment is now seen as a viable alternative in many water and wastewater applications.

<sup>5</sup> "Global Membrane Market for Water and Wastewater Treatment Forecasts and Analysis to 2015," Global Markets Direct, Nov 2009.

FILMTEC™ ECO RO Elements are the result of a combination of new science breakthroughs and technological advancements. The chemistry breakthrough hinges on re-engineering the polymer structure and composition of the product, while the technological upgrades in the feed spacer of the product ultimately lower energy and chemical consumption. There is currently no product in the market that can deliver water quality equivalent to that of FILMTEC™ ECO Elements at the same low pressure. When using other competitive products, industrial water producers have to compromise on quality or energy, resulting in increased operational expense.

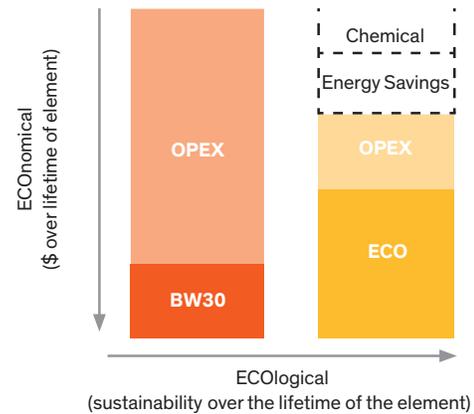
Gaining attention and international notoriety, FILMTEC™ ECO Elements have already won the 2013 Innovation Award at Aquatech China, as well as Pollution Engineering Editor’s Choice Award. With FILMTEC™ ECO Elements, a new kind of water treatment plant emerges, one that runs on less energy and reduces environmental stress and strain. FILMTEC™ ECO Membrane Module is designed with an ecological conscience. A typical process diagram of an industrial water treatment system is presented in Figure 1, and FILMTEC™ ECO Elements would be used in the primary loop in positions labeled “RO”.

**Benefits**

Plants that switch from conventional RO elements to FILMTEC™ ECO Elements have less impact on the environment and less strain on their bottom line. FILMTEC™ RO Technology enables robust performance over a longer lifetime through lower energy use, which reduces regeneration costs and results in operational savings between 16 and 19 percent. FILMTEC™ ECO Membrane Modules deliver up to 40 percent lower salt passage, while consuming 30 percent less energy than industry standard RO elements, resulting in an ecologic and economic win.

FILMTEC™ ECO Elements are ideally suited for industrial RO plants and replacement systems, allowing improved energy efficiency across a broad temperature range, operation with low energy membranes which enable savings from lower feed pressure, and offering high value and optimized performance. However, FILMTEC™ ECO Elements are gaining a global presence across a wide range of industries and industrial water applications, including:

- **Power:** Improves uptime and reduces chemical use for utility providers;
- **UltraPure Water:** Increases the rejection at lower feed pressure to accommodate increasing purity needs for electronic manufacturing;
- **Beer and Beverage:** Saves on energy use and chemical use and increasing capacity by improving uptime;



- **Mobile Units:** Creates highly compact, energy efficient operations with long-lasting performance, which is required in field locations.

**Unique economics**

Because FILMTEC™ ECO Elements provide such significant operational cost savings, Dow is able to offer new economic models for funding RO elements, a capital expense for customers. With a new financing partnership with DLL, Dow can now offer RO elements on lease, allowing customers to transfer capital expenditure into operational expenditure. Customers typically have long capital planning and funding cycles so this option presents a level of flexibility for Dow and its customers not yet seen in this industry.

The figure above illustrates how Dow can share the performance benefit of FILMTEC™ ECO Elements with its customers. An analysis of the economic value of the element over the lifetime of the element shows that chemical and energy savings are significant compared to standard products. Dow has taken this additional value and shared it with its customers while increasing margin per element by 60 percent compared to standard elements. For example, standard elements are priced at about \$500 per element while FILMTEC™ ECO Elements are priced at \$800 – \$1000 per element, which still presents significant savings for customers.

Based on current sales plans, we expect that in the next 10 years, this breakthrough technology will result in the production of over 10 billion cubic meters of clean water (the volume of over 4 million Olympic-sized swimming pools), while saving over 2 billion kilowatt-hours of energy and over 1.5 million metric tons of CO<sub>2</sub> emissions.

