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Transforming the digital space of desalination through the DuPont WaterApp, the FT-Norm PRO and the enhanced digital tools

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ABSTRACT

DuPont has recently released a new and improved digital tool to help plant operators normalize their data. This tool replaces the popular Excel-based data normalization tool that has been in use for over two decades. The new tool is user-friendly and easy to navigate. For a proper system performance assessment and optimization, ultrafiltration (UF) and reverse osmosis (RO) operating data normalization is vital in all systems which treat feed water with variable salinity and/or temperature. FT-Norm PRO (FilmTec™ Normalization of Membrane Systems) is a free online tool that makes the data normalization process simple yet robust enough to allow for effective monitoring of UF and RO systems. This tool helps plant operators explore how variations in feedwater temperature, salinity, or pump pressure can influence a membrane system's apparent productivity and rejection, making it more obvious when a real change in membrane performance occurs. This paper makes the audience to highlight the purpose and importance of data normalization in UF and RO systems, present the recently launched DuPont WaterApp and introduce the key tools to boost desalination plant performance through digital apps. Online tools assist users in quantifying their savings when using membranes with increased durability. Additionally, these tools can calculate the carbon footprint reduction achieved by implementing FilmTec™ dry seawater reverse osmosis membranes. Users can receive recommendations regarding the most suitable pre-treatment technology or membrane type and estimate the savings obtained using the novel DuPont™ B-Free™ pre-treatment technology to reduce biofouling in reverse osmosis systems. A reference plant, Alicante II Seawater Desalination Plant, will be used as an example to showcase the value of the digital apps. Thanks to the durability of the membranes and to correct operation and maintenance, this plant has been operating since 2008 without replacements.

Keywords: Digitalization; Reverse osmosis; Normalization; Tools

1. Introduction

Fluctuations in operating conditions such as water temperature changes, feed water quality changes, operating flux or system recovery settings will cause ultrafiltration (UF) or reverse osmosis (RO) permeate flow, feed pressure or RO salt rejection to change [1]. This is a normal phenomenon resulting of the changes in the operating conditions [2].

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But these fluctuations may interfere with detecting performance changes due to fouling, membrane aging or membrane damage [3]. Data normalization eliminates the effects of operating conditions fluctuations and allows monitoring of the system performance based on membrane properties alone, showing the true performance and status of the UF/RO membranes, isolated from the noise created by changes in operating conditions [4].

After more than two decades of providing data normalization with its popular Excel-based data normalization tool, DuPont launched the new online FT-Norm PRO tool in August 2021, a completely digital, user-friendly and revamped tool to allow plant operators to normalize their data, regardless of what brand of membranes they are using. This tool is available at the www.dupontwaterapp.com [5].

In addition, the DuPont WaterApp also gathers a broad range of user-friendly digital tools that can help water purification engineers, from exploring the best pretreatment solution for a seawater desalination plant to optimizing membrane cost and carbon footprint in desalination plants.

This paper aims to describe the use and benefits that these digital tools offer to desalination plant users.

To demonstrate the process, we will use the Alicante II Seawater Desalination Plant as a reference plant.

2. Alicante II Seawater Desalination Plant

The Alicante II Seawater Desalination Plant (SWRO) was designed to produce 65,000 m^3/d of permeate with a boron content below 1 ppm. The SWRO plant is provided with 7 seawater reverse osmosis (SWRO) racks. Each rack consists of 128 pressure vessels with six FilmTec™ SW30HRLE-400 elements in the front position and one FilmTec™ SW30XLE-400i element in the last position of the vessels. According to the design, the plant operates at an average flux of 12.1 $L/m^2{\cdot}h$ with a recovery of 44%.

The Alicante II SWRO plant was started up in May 2008 and, during the first days of operation, plant performance fully met the expectations in terms of both quality and quantity of the permeate. However, short after the start-up, it was observed that the normalized permeate flow and the normalized salt passage tended to continuously decrease until reaching a constant value. The normalized permeate flow decreased around 30% while the normalized salt passage decreased approximately 70%. More specifically, the normalized permeate flow dropped from around 410 to 260 m^3/d during the first weeks of operation. On the other hand, the normalized salt passage decreased from 0.6% to 0.15%. This behavior was observed in all the trains.

To restore the permeability of the membranes, several cleaning protocols were tested in the lab facilities of DuPont Water Solutions. Based on those results a cleaning protocol for the membranes was proposed. This product was applied in the reverse osmosis racks of the SWRO desalination plant of Alicante II. As a result of the cleaning, the normalized permeate flow of the plant was fully restored while maintaining an excellent quality of the produced permeate, which was far below the predicted values. The plant's performance from the start-up up to date will be evaluated with the help of the FT-Norm PRO tool.

It is also noteworthy that, since the start of the = operation in 2008, the plant has not changed any reverse osmosis element in any of its racks. This has allowed the optimization of plant productivity and production costs, resulting in significant economies. Frequent or premature membrane replacements increase expenses mainly due to the cost of new membranes and manpower for installation, halt in water production while installation is underway, disposal cost, and optimized operations during the startup phase.

3. FT-Norm PRO tool

3.1. Method

The online application, launched in August 2021, enables customers to go fully digital and have their plant operating data stored in the cloud, where Water DuPont experts can help plant operators to understand and anticipate potential operational issues and trigger the implementation of early corrective measures (such as initiating a maintenance cleaning in place program). In addition, unlike the conventional Excel-based tool, the customer does not have to deal with cumbersome spreadsheets that could easily become very large and difficult to manage or become corrupted.

Some of the key features of this new online normalization tool are:

- Web-based;
- Available for PCs and mobile devices;
- Users can record multiple installations;
- Intuitive menus for data introduction;
- Customizable charts for easier data interpretation;
- Allows multiple-stage RO systems;
- Possibility to share the operational data with other users;
- Data can be imported from existing files and exported to spreadsheet and pdf files;
- Capability to directly request technical support.

3.2. Results and discussions

FT-Norm PRO offers a simple interface, as shown in Fig. 1. It also allows the user to graph different parameters (normalized permeate flow, normalized salt passage and salt rejection, and normalized pressure drop, among others) showing plant performance in real time.

Fig. 2 shows the operational data corresponding to one skid of Alicante II SWRO desalination plant. As can be seen, FT-Norm PRO easily allows to assess the performance of the plant by evaluating the behaviour of key indicators:

- Normalized permeate flow showed a pronounced drop shortly after start-up which was reversed after a specific cleaning. Since then, permeate flow has remained very stable during the last 12 y.
- In parallel to normalized permeate flow, normalized salt passage also showed a pronounced drop shortly after start-up. After normalized permeate flow was restored, membranes maintained an excelled quality of the produced permeate with salt passage below the expected values. Normalized salt passage shows a very slight

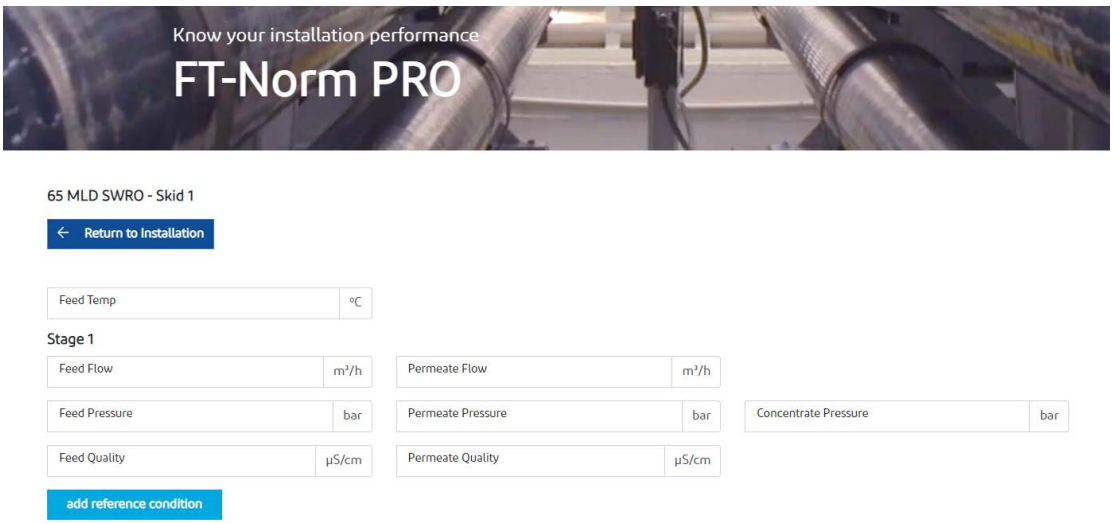

Fig. 1. Example of data introduction entry? for a 1-stage reverse osmosis system.

Fig. 2. Example of normalized performance data trends display.

increase along the whole time of operation of the plant. Despite this effect, salt passage values are below the start-up/reference values most of the time.

- Normalized pressure drop values have been quite stable and within acceptable values.

Knowing the evolution of normalized permeate flow, normalized salt rejection and normalized pressure drop is of utmost importance since this enables the early diagnosis of any possible problem of fouling (organic, biofouling, scaling or particulate fouling) or membrane deterioration.

4. Other tools to enhance desalination plant performance

Besides FT-Norm PRO tool, The DuPont WaterApp offers multiple tools to improve desalination plant performance. These are:

4.1. Invest to save calculator

The invest to save calculator allows the user to determine the savings they will obtain by using membranes with a higher durability. Investing in high quality,

durable technology upfront can save operations from incurring high costs over the lifecycle of operations.

Taking as an example a SWRO Plant with a capacity similar to that of Alicante II, Fig. 3 shows the inputs for the Invest to save calculator.

As can be seen in Fig. 4, for this example, despite the higher initial membrane cost, thanks to the higher durability, $3.9 MM could be saved in membrane replacements. In terms of sustainability, this prevents the disposal of 7,800 membranes as a solid waste.

4.2. Dry seawater sustainability calculator

Dry seawater sustainability calculator allows the user to calculate the carbon footprint a desalination plant is achieving thanks to using the dry seawater reverse osmosis membranes. This is possible thanks to the lighter weight these membranes have, which enables reduced transportation cost and therefore reduced CO_2 emissions.

Considering the example of the Alicante II SWRO Plant, if 6,272 seawater reverse osmosis elements were supplied

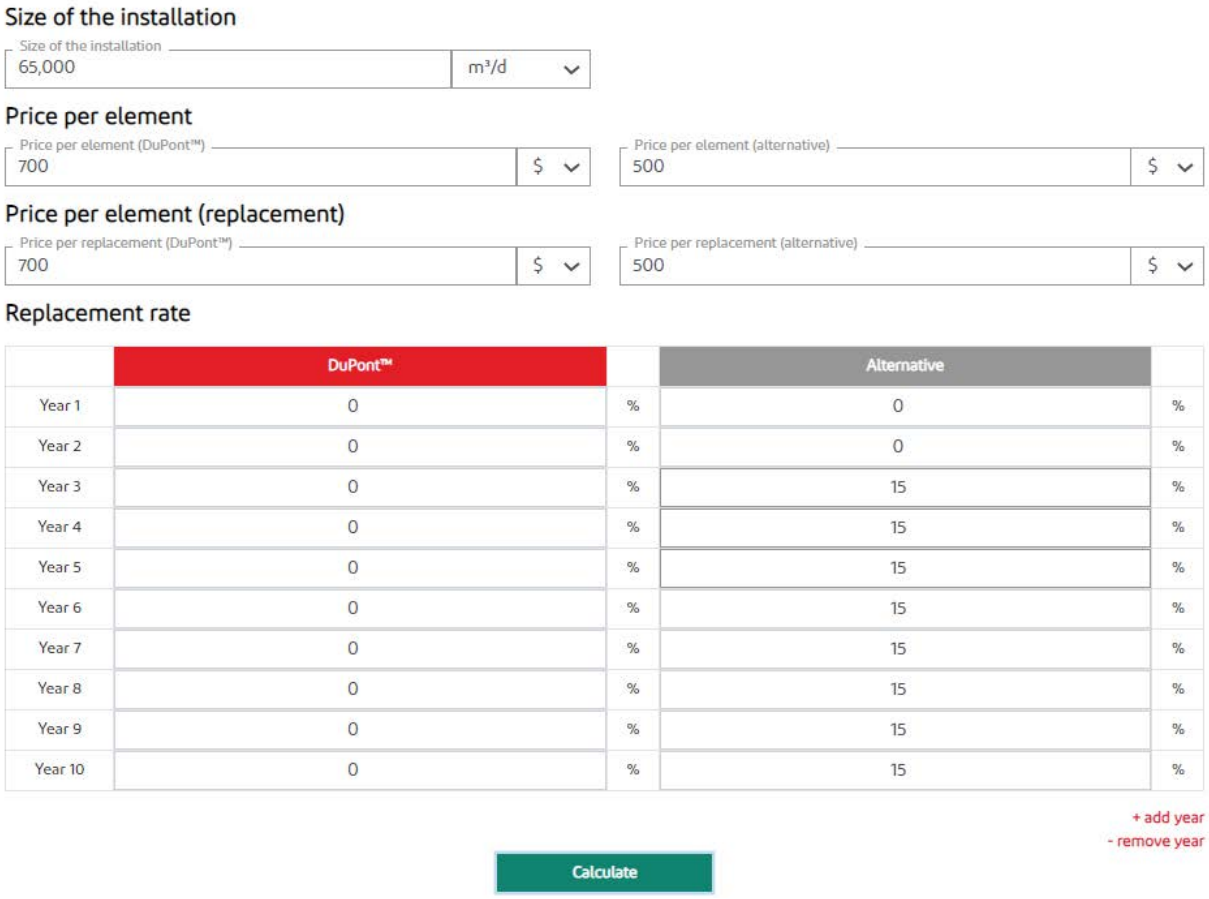

Fig. 3. Invest to save calculator. Inputs.

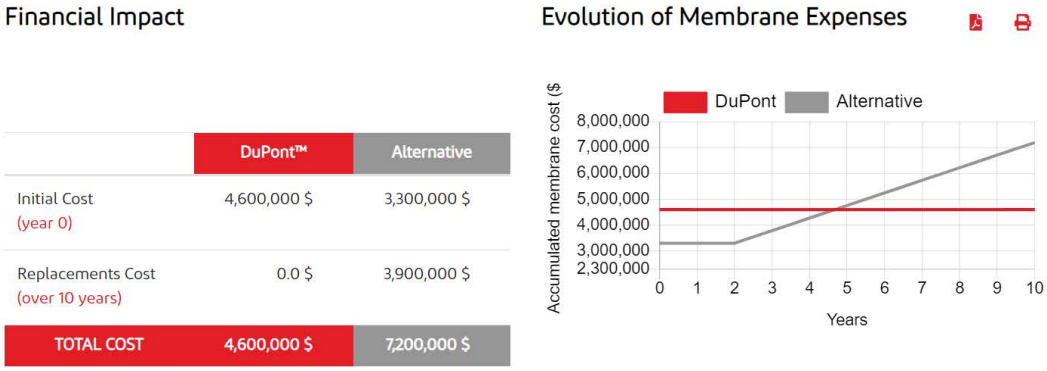

Fig. 4. Invest to save calculator. Results.

dry instead of wet, ≈17 tons of CO_2 could be saved, the equivalent to burning 8 tons of coal or driving more than 64,000 km in an average passenger vehicle. Fig. 5 shows the easy-to-use interface of the dry seawater reverse osmosis sustainability calculator.

4.3. Pre-treatment advisor

Pre-treatment advisor allows plant operators to understand the best pre-treatment technology prior to the reverse osmosis, based on what they need to achieve. As Fig. 6

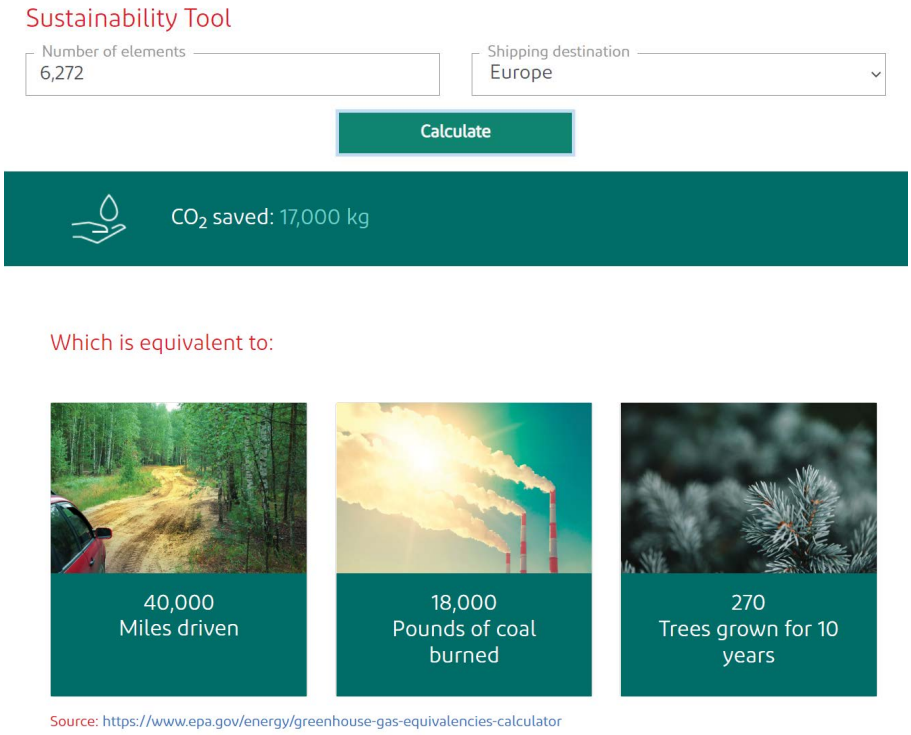

Fig. 5. Dry seawater reverse osmosis sustainability calculator.

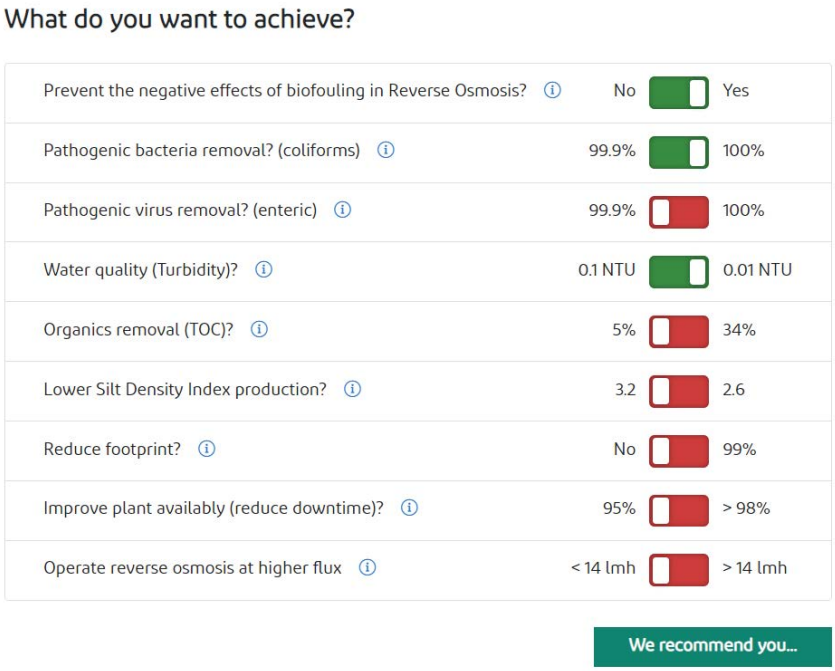

Fig. 6. Pre-treatment advisor.

shows, with simple questions, user will be able to know if ultrafiltration, sand-filter or DuPont™ B-Free™ technologies are recommended as pre-treatments.

4.4. Desal advisor

Desal advisor lets you understand, from very simple questions, what membrane type is recommended for a desalination plant. Just by clicking on the pre-treatment steps, the first pass or the second pass of a desal plant, and answering simple questions based on what the user wants to achieve, the Desal Advisor will recommend the best membrane type without needing to upload any technical information.

For example, Fig. 7 shows the questions that the user will need to answer to evaluate the best ultrafiltration technology. Fig. 8 shows an example of the recommendations based on the user inputs in Fig. 7.

4.5. DuPont™ B-Free™ sustainability

DuPont™ B-Free™ is a novel pre-treatment designed to prevent biofouling in reverse osmosis systems. The DuPont™ B-Free™ Sustainability tool enables the user to calculate, from a single click, the CO_2 savings, the chemicals saved, and the wastewater saved thanks to eliminating biofouling from reverse osmosis plants. In the example shown in Fig. 8, the results in Fig. 9 indicate that that for a 10,000 m^3/d plant, 26 tons of CO_2 can be saved, as well as 12 tons of chemicals and 4.2 tons of water.

5. Conclusions

UF and RO system data normalization is a long-established powerful technique that allows for the assessment of performance based on membrane properties alone, showing the true performance and health of the membranes,

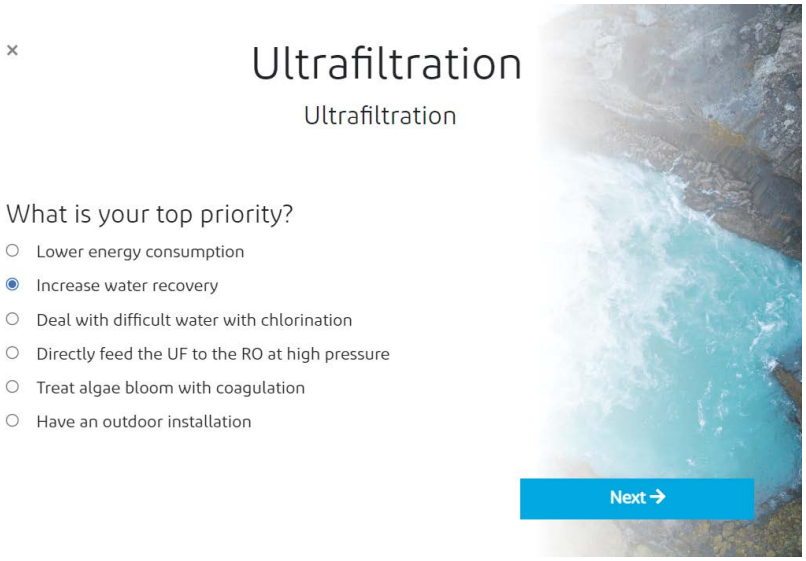

Fig. 7. Desal advisor. Ultrafiltration.

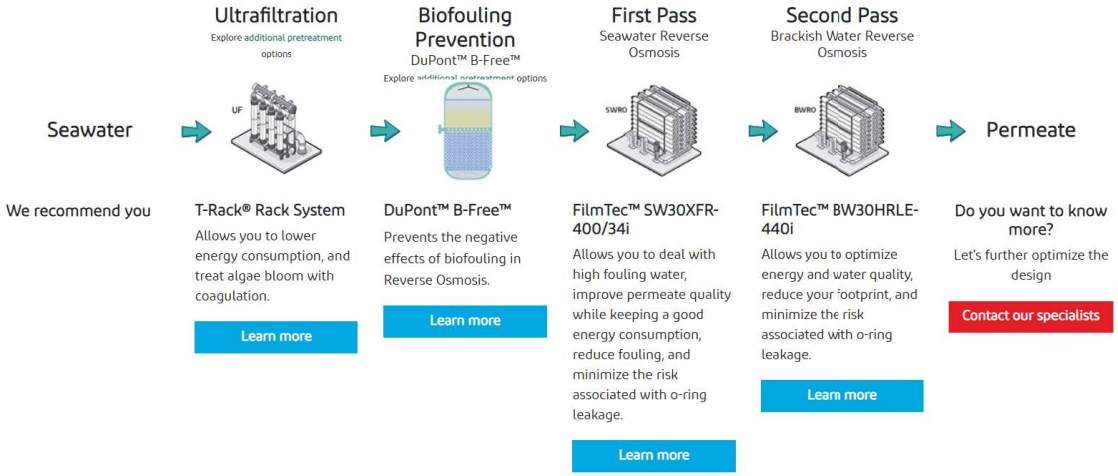

Fig. 8. Desal advisor. Recommendations.

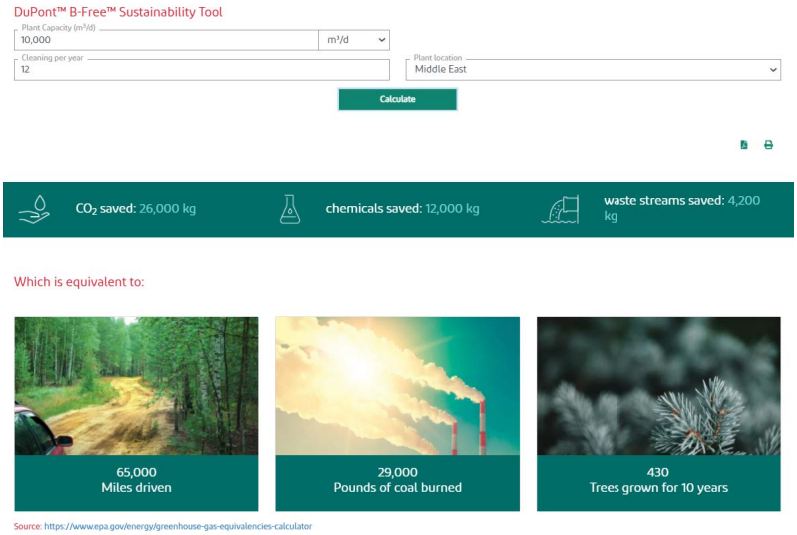

Fig. 9. DuPont™ B-Free™ sustainability calculator.

isolating these parameters from the interferences created by changes in operating conditions. In particular, data normalization helps identify potential problems such as membrane fouling or membrane degradation and triggers the implementation of adequate and timely corrective measures.

After more than two decades of providing its widely used and well-known Excel-based data normalization tool, DuPont has launched the new FT-Norm PRO, an innovative online version of the data normalization tool, completely digital, web-based, user-friendly and modernized, to help plant users monitor and optimize their systems, regardless of what membrane brand they are using. The importance of data normalization in UF and RO systems as well as the key features of the FT-Norm PRO have been presented.

In addition, this paper has also introduced other digital tools available in the DuPont WaterApp. These digital apps will allow the users to boost the performance of seawater desalination plants by helping them to:

- Quantify the savings obtained by using membranes with higher durability. The example of the Alicante II SWRO plant has been considered to showcase the invest to save calculator. The Alicante II SWRO plant has been operating since 2008 without membrane replacements. In the presented example it was estimated that, despite the higher initial membrane cost, thanks to the higher durability, $3.9 MM were saved in membrane replacements. In terms of sustainability, this prevented the disposal of 7,800 membranes as a solid waste.
- Calculate the reduction in carbon footprint that a desalination plant can achieve by using the innovative FilmTec™ dry seawater reverse osmosis membranes.
- Obtain recommendations in terms of best suited pre-treatment technology or type of membrane.
- Estimate the cost and time savings that can be obtained when reducing biofouling in reverse osmosis systems by using the novel DuPont™ B-Free™ technology.

References

[1] Y. Zhao, J.S. Taylor, Assessment of ASTM D 4516 for evaluation of reverse osmosis membrane performance, Desalination, 180 (2005) 231–244.
[2] K.H. Chu, J. Lim, S.J. Kim, T.U. Jeong, M.H. Hwang, Determination of optimal design factors and operating conditions in a large-scale seawater reverse osmosis desalination plant, J. Cleaner Prod., 244 (2020) 118918, doi: 10.1016/j.jclepro.2019.118918.
[3] H. Boulahfa, S. Belhamidi, F. Elhannouni, M. Taky, A. El Fadil, A. Elmidaoui, Impact of the raw water seasonal variations on the reverse osmosis performance: Khenifra plant, Morocco, J. Water Environ. Technol., 17 (2019) 359–374.
[4] M. Kim, B. Park, Y.J. Lee, J.L. Lim, S. Lee, S. Kim, Corrected normalized permeate flux for a statistics-based fouling detection method in seawater reverse osmosis process, Desal. Water Treat., 57 (2016) 24574–24582.
[5] www.dupontwaterapp.com, Consulted on 15 February 2022.