Americas Sustainable Development Foundation

WHITE PAPER

THE DEEP-SEA WATER INDUSTRY POTENTIAL IN THE CARIBBEAN

A Circular Economy compatible industry to address future water, energy, and food needs in Caribbean island nations

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Disclaimer

The intention of this White Paper is to ensure the rapid dissemination of this conceptual proposal.

This paper has been written by ing. Kevin de Cuba, MSc., Director and Senior Advisor at the Americas Sustainable Development Foundation, which takes full responsibility for the paper's content and conclusions. This paper will be followed by more in-depth working papers.

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The Deep-Sea Water Industry potential in the Caribbean

A Circular Economy compatible industry to address future water, energy, and food needs in Caribbean island nations

by ing. Kevin de Cuba, MSc [1]

Access to fresh, clean, and affordable water, energy, and food on island states is increasingly becoming a challenge across the globe. This can be solved by simply observing and realizing that the ocean that surrounds your island is the potential source of the solution to all these challenges. Imagine developing a new economic pillar that can help your island overcome the need to provide these basic needs through a circular and sustainable economic industry or sector.

Many island nations, such as Aruba, are confronted with significant sustainable development challenges, as their economies are based on the premise of a continuously expanding tourism sector, electricity generation and transport that are mainly or completely reliant on expensive fossil fuels, limited agricultural activities and increasing or full dependency on food imports, as well as limited access to natural fresh water sources and expensive water treatment, small scale fishing industries affected by global fish decline, brain drainage due to lack of attractive, progressive and innovating economic activities, among other. These are significant challenges to guarantee a good livelihood for the island community and sustainable development.

Recognizing these sustainable development challenges, the business community in Caribbean island nations is in the unique position to serve as a key enabler to address these challenges by seriously engaging in the exploration and exploitation of the ocean resources. One very attractive market opportunity, is creating primary and secondary productive activities from Deep Sea Water (DSW) pumped to the shores and use this resource in a sustainable manner creating added value in a circular island economy, while making a profit.

What is a Circular Island Economy?

A Circular Island Economy is an island economy that is restorative and regenerative by design; that aims to keep products, components, and materials at their highest utility and value at all times; that distinguishes between technical and biotic nutrients that flow through the economy in different closed looped cycles; that decouples economic growth and development from the excessive consumption of natural resources; and that promotes job creation and social wellbeing to achieve sustainable development (adapted from; Ellen MacArthur Foundation, 2016).

As shown in Figure 1 the goal is to re-define the global economic model and shift from a linear “take-make-use-waste” destructive model to a non-linear economic model where technical and biotic nutrients flow through the economy in cycles and generate benefits or become assets for indefinite cycles of productive and healthy use.

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Figure 1. From a linear to a non-linear economic model composed of biological and technical nutrient cycles

Circular Economy is inspired by a combination of schools of thought including Cradle to Cradle, Performance Economy, Biomimicry, Industrial Ecology, Natural Capitalism, Blue Economy, and Regenerative Design. Its guiding principles are derived from the learnings and principles developed by the above-mentioned schools of thought.

It is estimated that Circular Economy has a great potential, with over one trillion US dollars in business opportunities through material savings, increased productivity, new jobs, and new products, services and businesses (World Economic Forum, 2016).

How does a Deep-Sea Water Industry fit within a Circular Economy?

A Deep-Sea Water Industry (DSWI) is found to be a sustainable macro-economic solution that is very compatible with the vision of a Circular Island Economy and is defined as “an island-compatible economic sector where innovative and sustainable solutions and productive activities are developed, driven by the use of the surrounding deep-sea water” (Sewenig, 2016).

This industry is based on the objective of closing the loop between an island economy and surrounding ocean water, through the pumping of cold DSW of 4-6°C at 800-1000 m depth to the shore, and circulate this in either closed-loop or cascading systems as means to address among other, energy, water, and food needs in locations where the conditions are optimal, prior to returning the water back to the ocean.

Having unlimited access to an eco-friendly and renewable source within your maritime boarders, makes DSWI an island-compatible and self-sustaining economic sector where innovation and sustainability are at the epicenter of all activities within this sector.

Macro-economic and socio-environmental benefits of a DSWI

From a macro-economic standpoint, a DSWI contributes to the diversification of an island economy and helps building resilience to external shocks as most island economies are dependent on a single economic pillar (e.g. tourism) and are highly reliant on expensively imported goods, products, and other resources.

But what makes this industry attractive is that as well as building resilience and increasing energy, water and food security, there is a potential for converting island economies in net exporting economies based on

production of high-end or value-added products (cosmetics, biopharmaceutical products, bio fuels, and other types of products) using naturally available resources (including the characteristics of DSW) and conversion processes running on an eco-friendly and clean renewable source, which is the ocean water.

A DSWI represents a combination of sectors and disciplines, not only for commercial and productive interests, but also to contribute with research, development, education, thus the overall science in the use of DSW and other deep sea marine flora and fauna. In this way, it is possible to attract research institutes and universities to the island to build expertise and launch a knowledge-based sector attached to this DSWI. Such a DSWI with its interrelated secondary activities can employ at least 400 – 600 direct permanent jobs (Sewenig, 2016) and thousands of people during design, development, construction, installation, operation, maintenance, and expansion which can be significant in an island community.

A DSWI also serves as a magnet for entrepreneurs for the creation of startups, research and development agencies, and other companies with foresight willing and able to endeavor into a completely new and untapped DSW related industry, and investors interested in facilitating the process of transitioning from performing research to commercialization of findings and solutions. The creation of a knowledge hub in the Caribbean will not only promote innovation, but also creation of high paying specialized jobs to retain well-educated or highly skilled professionals from the region.

By enabling the cultivation of fruits and vegetables on the island through modern technologies with low (negative) ecological footprints, the import and therefore the transportation of fresh produce and/or the need to consume conserved food is reduced. These offset a significant amount of greenhouse gas (GHG) emissions, as the frequency or capacity of marine vessels running on fossil fuels to supply goods and products is reduced.

Also, because the main driver of a DSWI is the ocean water, the complete system operates on a renewable resource that does not contaminate or lead to significant environmental impacts during its use cycle. In line with the definition of Circular Economy, a DSWI can contribute in the regeneration or restoration of fish stock in surrounding waters, by creating nursing ponds and/or use the DSW in intelligent cascading loop to nurture critical ecosystems, such as mangrove forests that serve as nursing areas for small fish and other marine life.

Briefly, the interesting opportunity behind a DSWI lays in the fact that this highly valuable DSW that has already been pumped to the shore and has become a non-contaminated and still relatively cold by-product, can still be exploited for many additional productive uses. Not only to create new or additional revenue streams, but also making the investment in a district cooling or an ocean thermal energy conversion system more attractive and profitable.

Thus, in a DSWI, instead of typically discharging the relatively cold DSW directly back into the ocean after extracting the temperature gradient, it is utilized for additional economic activities in a circular and/or cascading system, e.g. for fish and seafood rearing, agriculture, or fresh water production (Sewenig, 2016).

Due to the hybridization of technologies and economic uses for the exploitation of the DSW within a circular DSWI park, this opens new avenues to larger scale and multi-disciplinary processes where a variety of businesses, technology providers, investors, and stakeholders can find an added value or exploit a market niche.

DSWI and Energy

When looking at a DSWI from the perspective of how the technologies used in such an industry can contribute or solve critical needs in the electricity generation and transport sector of island nations a brief descriptive summary is provided below.

- A DSW district cooling system can lead to significant energy savings (up to 30% in energy savings) in large buildings, such as hotels, hospitals, airports, or other types of office buildings. In the warm Caribbean climate, cooling of spaces is critical. This has an overall positive effect on many island nations that depend on the tourism sector, where hotels and other accommodations represent the largest energy consumers category on such islands and are continuously striving to reduce the cost of services to remain competitive in a highly competitive tourism market.
- On another front, looking at the general sustainable energy development ambitions of many island nations, typical intermittent renewable energy technologies increasingly being deployed in island nations, such as Solar Photovoltaic systems and Wind Turbines, are highly dependent on baseload energy supply options. To achieve island-wide 100% renewable energy generation, there is a critical need for sustainable baseload power supply solutions. This is currently being addressed by investing in energy storage technologies, making conventional fossil-fuel based energy generation technologies as efficient and reactive as possible, and grid optimization and real-time management options. But a DSWI park using an Ocean Thermal Energy Conversion (OTEC)[2] system as the back-bone technology brings the best of all worlds. This is because an OTEC system can provide baseload power supply running on a clean and renewable source which is the temperature gradient determined by the ocean water depth. This is next the geothermal energy, the only two sustainable island-compatible energy technologies available to the Caribbean islands to supply baseload power to achieve a complete transition to a sustainable power generation and supply system.
- In the transport sector, through a DSWI, there is the opportunity to cultivate algae at industrial scale to convert into biodiesel to offset the need for diesel or other fossil fuels on island, but more interestingly position yourself as a net-exporting biofuel nation while running your industry on renewable DSW.

DSWI and Water

Through several technology options, fresh water can be produced in a DSWI park. Depending on the backbone technology opted, there are different configurations possible to produce fresh water. In the case of the use of an open-cycle or hybrid designed OTEC system, the DSW effluent from the system can be desalinated, bottled, and sold on the local and international market. Another way to produce fresh water is through dew collection or the dehumidification of the air that can be used for agricultural purposes or landscaping.

Independent of the opted backbone technology and configuration of the DSWI park, Caribbean islands with suitable conditions can gain the following benefits with fresh water production:

- Generate significant revenues through the desalination and bottling of DSW. There are several examples, like in Hawaii and Japan, where this is a very profitable sector and significant contributor to islands GDP;
- While dehumidified water quality is not drinking water quality, it can be used for crop irrigation and allow for

[2] An Ocean Thermal Energy Conversion (OTEC) system uses the net difference in temperature (between the cold deep-sea water and heated surface water) to generate baseload power in a conventional steam-cycle.

the cultivation of fruits and vegetables in modern greenhouses or other technology configurations with low footprint and offset expensive imported food; and
- Dew collection can also add fresh water reserves to the islands' fresh water supply security, this is of critical importance to islands that highly or fully depend on fossil fuel-based sea water desalination systems, such as Aruba.

DSWI and Food

Agricultural and aqua cultural activities are enabled within a DSWI. Examples include the circulation of DSW in closed-loop underground piping in areas where the soil is naturally not suitable for plant growth, but by making the soil cooler and moist, this enables the cultivation of vegetable plants. Also using the DSW as effluent can be tapped to supply fish ponds and other dedicated facilities for algae production or other types of biomass.

Independent of the opted backbone technology and configuration of the DSWI park, Caribbean islands with suitable conditions can gain the following benefits related to food production:

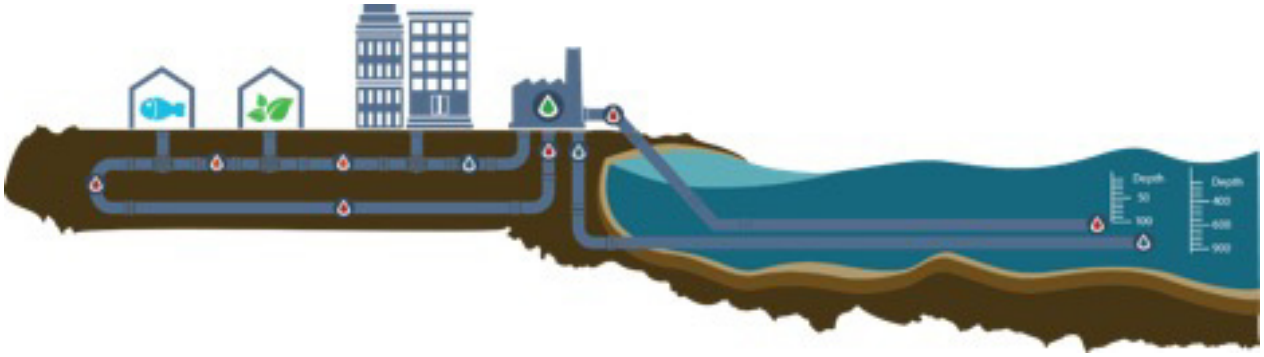
- Enable aquaculture development that can help overcome overfishing and species exploitation in oceans, and eventually contribute to fish stock recovery;
- Aquaculture that allows Caribbean islands to among other increase food resources and production on the island, and diversify the economic activities and reduce import expenses;
- Creation of job opportunities on the island and beyond, and gain expertise and skills to transfer among other islands and coastal nations;
- The opportunity to create add-on economic sectors, such as "upstream industries" which include for instance agriculture, hatcheries, feed manufacturers, equipment manufacturers, and other ancillary services; and
- The opportunity to create "downstream industries" including processors, wholesalers, retailers, transportation and logistics, and food services, among other.

The Challenge

Although in principle this DSWI proposal is a rational and an all-inclusive integrated solution, its realization is not an easy task. Globally there are limited examples of full scale operational industrial parks running on DSW. This industry requires a large capital investment to set up, as it depends on an extensive infrastructure to pump and circulate the DSW in an intelligent piping network to be distributed and cycled among multiple interacting actors to make cost-effective use of the valuable characteristics of this DSW.

The benefit of such a system is that it is flexible and can be tailor-made or configured to the conditions and needs of the island economy and is compatible with conventional district cooling systems, ocean thermal energy conversion systems or other ocean energy exploiting technologies. This is because the DSW can typically be used to condensate the working fluid in an Ocean Thermal Energy Conversion (OTEC) cycle after it has powered a turbine for power generation; or the cold DSW can also be used to cool down the water in the circular loop of a district cooling system or a sea-water air conditioning system (SWAC)[3] . After its use, typically this higher temperature DSW is returned to the ocean. Please see the figure below for an illustration of a DSWI with a SWAC system as back-bone technology.

Illustration of a DSWI + Sea-water Air Conditioning System



The above means that a DSWI park goes hand in hand with the development of either a district cooling system, an ocean thermal energy conversion system or other technologies that can exploit the DSW in the surrounding ocean. To justify investments in the piping network and other needed infrastructure for a DSWI it depends mainly on the selection of the primary or so-called back-bone technology, its technical capacity to supply a critical volume of cold DSW for the development of a DSWI, and the technologies' economic performance as a stand-alone solution.

Because of the limited number of operational DSWI in the globe, there is very limited technical and economic data and information to make informed decisions. In addition, the high capital investment for the back-bone technologies is a challenge to the development of a full scale DSWI park. In the case of opting for an OTEC system as back-bone system, the installation cost falls between 16.4 – 35.4 kUS$/kW for 1-10MW installed capacity and becomes lower with increasing capacities (Sewenig, 2016). Likewise, the investment costs for SWAC systems ranges between 4.3 – 39.5 kUS$/ton Air-Conditioning (AC) load for systems requiring between 4,000 ton to 28,600 tons of AC load (Sewenig, 2016). Because each system is unique and has its own configuration, this range of potential investment costs, is not suited to adequately assess the capital investment of a specific island system but places it in the margins of the hundreds of millions of dollars.

The way forward?

Caribbean islands are uniquely positioned to endeavor in the development of Deep Sea Water Industries to realize circular island economies, as they are located in an optimal climatic zone with year-round stable temperatures, have access to an untapped and renewable resource located within their economic territory, are confronted with energy, water and food supply challenges, and are in need of creating new and additional economic sectors for job creation and knowledge and expertise development to make the island economies less import dependent and more resilient to external shocks.

[3] A Sea-Water Air Conditioning (SWAC) system is an energy efficient way of air conditioning where instead of using electricity to cool down the process water in a conventional system, cold deep sea-water is used to remove the heat from the process water loop.

From a macro-economic and socio-environmental perspective the rationale for the development of island-compatible DSWI as part of a Circular Island Economy vision is more than convincing. But to concretely move toward the realization of a DSWI in the Caribbean, both local and international investors and entrepreneurs with foresight must step up and lead the next steps in financing or securing financial resources to perform further detailed investigations, and obtain more technical feasibility data and information to confirm the technical and economic viability of the back-bone technologies. Also, engagement with strategic partners in building a consensus and critical mass of support for the development of a DSWI is needed.

In addition the proactive involvement of the larger financial institutions and development banks (recognizing the Latin American Development Bank – CAF as one of the few active in this field) is critical to assign funding and explore ways to access capital to address the large-scale capital investments needed in setting up such a system in island nations that are typically confronted with high debts, non-unified strategic development plans, and the need of adequate regulatory frameworks and securities for investors.

Regardless of the island situation or past economic development pathway, the goal of optimizing the use of domestic natural renewable resources such as ocean water to drive a completely new economic sector is one that needs to be taken into serious consideration in any future development scenario. In this global linear economic system, continued access to raw materials and fossil fuels are going to increasingly become more complicated, costly, and unreliable to drive modern technology-based economies, while generating unwanted socio-economic and environmental consequences.

Small island nations, as Aruba, do not and will not have the bargaining position to compete for ever scarcer resources, and secure access and supply of materials, products, and goods to guarantee a proper livelihood of their island communities. Therefore, it is important to focus on island-compatible and self-reliant ways to continue to guarantee access to core primary needs which are fresh water, food, and energy services by switching the island economy to one based on circular economy principles (regenerative and restorative by design and intent), and that can be driven by natural resources which are generously available in our surrounding oceans.

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