The future of energy business in a circular economy

IBM

Executive summary

The Circular Economy is an economic model that emphasizes leasing, recycling, refurbishing, repairing, reusing, and sharing existing materials and products for as long as possible. The lifecycle of products and their components are extended, thereby reducing waste as well as the need for virgin materials. It is a departure from the traditional linear economic model, that has a take-make-consume-dispose pattern relying on large quantities of cheap and easily accessible materials and energy.

Global energy demands are shifting towards electrification and renewables, and the Energy and Utilities sector is already an active participant in the reduction of extraction-based operations in terms of generation. Adopting the circular economy model expands this thinking to the assets and materials used to generate, transmit and distribute energy—and mechanisms to inspire customers to do the same.

As consumer and regulatory expectations increase, participation in the circular economy business model is a challenge facing energy and utilities businesses today. This paper offers examples of innovative solutions applying circular economy principles and touches upon ways that IBM technologies can be a catalyst for change.

Market trends and business imperatives

Embracing and implementing the concept of a circular economy for energy and utilities is challenging. It has been more than 3 decades since the term was first coined and the current concern for climate change continues to heighten the urgency to expand the role of the circular economy. With increasing consumer demands across a variety of industries, businesses are finding it challenging to fully participate in the circular economy business model. On one hand, organizations are passionate about making a sustainable change in their businesses and critical industrial processes, but on the other hand, they often lack the breadth of expertise required to bring about such a change.

There has been a significant shift in the mindset regarding the effect consumption and production is having on the environment. It is well documented that 75% of natural resource consumption is occurring in urbanized metropolitan areas, producing 50% of global waste and 60-80% of greenhouse gas emissions [1].

A measure of the serious need for pursuing a circular economy is the annual Earth Overshoot Day which marks the date when our demand for ecological resources and services each year exceeds what can be regenerated. In 2021, that day was accelerated to 29 July, which provides a sense of urgency with regard to the need for addressing ecological changes [2].

The energy and utilities industry is recognized as a key player adressing the ecological need for a circular economy, e.g. by supporting smart cities initiatives through advanced energy management, supporting sustainable urban living (light on demand, smart integration of electric vehicles), supporting smart and sustainable homes (low emission heating), and smart planning for optimal placement of wind turbines and photovoltaic panels.

Electricity demand is expected to double between 2018 and 2050 [3]. And for most countries, carbon reduction targets have been established by law (176 countries now have carbon reduction targets according to Morgan Stanley, Utility 2.0, 2017). Clean electricity is the new fuel of the world, requiring a fundamental architectural change witnin the energy and utilities business.

In Europe, for example, we see a distinct startup scene focused on circular economy, partly fueled by the European Green Deal Investment Plan—also known as the Sustainable Europe Investment Plan—which is designed to attract at least €1 trillion worth of public and private investment over the next decade to make Europe climate neutral by 2050 at the latest [4]. This target and investment plan is leading to many new, innovative solutions that has the potential to impact businesses including the energy and utilities industry. Data-driven solutions and important trends, (e.g. waste to energy by incineration, gasification and other technologies) will have a transformational impact on energy companies.

A few examples may underline this:

- Singapore has been a pioneer in promoting the circular economy and is investigating ways to convert waste materials such as liquified waste plastics into jet fuel by 2022. Moreover, other developments in treatment facilities, transport infrastructure and industrial facilities have set the stage for Singapore to meet its zero waste and low-carbon emission strategies [5].
- There is a strong global focus on reducing gas flaring to a bare minimum. The World Bank's Global Gas Flaring Reduction Partnership (GGFR) is a multi-donor trust fund composed of governments, oil companies, and multilateral organizations committed to ending routine gas flaring at oil production sites across the world. The Zero Routine Flaring (ZRF) has already won support from several country heads and large corporations. The ZRF initiative commits to end routine flaring to 0% by 2030 [6].
- The EU had set an ambitious target for renewable energy and has reaped the benefits. In 2019, renewable energy represented 19.7% of energy consumed in the EU-27, only 0.3% short of the 2020 target of 20%. The EU has set their next goal through the Renewable Energy Directive which sets rules for the EU to achieve its 32% renewables target by 2030 [7].

Business imperatives

With the push to enforce sustainable practices and assimilate them within their mission statements, various organizations are taking different measures. Here are some examples:

- Iberdrola is one of many energy and utility companies integrating sustainability into their business model [8].
- Siemens has set a target that all their production facilities and buildings worldwide are to achieve a net-zero carbon footprint by 2030 [9].
- Schneider Electric uses recycled content and recyclable materials in its products, prolongs product lifespan through leasing and pay-per-use, and has introduced take-back schemes into its supply chain. Circular activities now account for 12% of its revenues and will save 100,000 metric tons of primary resources [10].
- In Enel's "Circular Smart Meter" project, plastic and copper from old smart meters are reused in the construction of new smart meters. This approach is part of the "Circularity by Design" approach, which leads to minimizing the use of natural resources and to lower costs over the entire lifecycle. This approach can be applied to other network infrastructure elements, such as cables, transformers, and protection devices [11].

(Further examples [10] and [12])

There are many new players in the market with different products and business models around the circular economy. For instance:

- The US-based company Redwood Materials is creating a circular supply chain by retrieving, recycling, and recirculating raw materials such as cobalt, copper and nickel from end-of-life batteries [13].
- The UK-based company Aceleron has developed a technology to produce sustainable lithium battery packs [13].
- The Canadian company Enerkem extracts carbon from trash that can't be recycled and turns it into gas that can be used to make biofuels [10].
- Adopting digital traceability for sustainable production, and connecting manufacturers, suppliers, consumers, and regulators. These initiatives should be focused on jointly establishing solutions and supporting ecosystems to increase supply chain visibility and accelerate sustainability and circularity across manufacturing and production [14].

(Further examples in [10] and [12])

Enablers – cultural and regulatory influences

Climate change is no longer a concept of the future – the world is currently experiencing many extreme weather events already. For example:

- There is a documented relationship between rising global temperatures and human mortality attributed to heat-related deaths. This phenomenon is observed globally, with higher rates in underdeveloped countries where air-conditioning is not prevalent due to the lack of reliable electricity [15].
- Due to climate change, many regions and countries are increasingly suffering from water scarcity and droughts with negative impacts on agriculture, water supply, energy production, human health, and other aspects of society. According to the WHO, 55 million people worldwide are currently affected by drought each year [16].

In parallel, we are seeing an evolution of social norms and values–cost is not the only factor in a purchase decision. A premium may be charged for products and services that demonstrate a sense of responsibility and environmental awareness. For example, consumers who are willing to pay slightly more for energy that is aligned with their environmental values have responded favorably to electric utilities offering "green" energy, either through owned generation or the purchasing of Renewable Energy Certificates (RECs) from other generators on their customers' behalf [17].

Governments have been introducing legislation to encourage lifecycle thinking for some time. The UK's Landfill Tax was introduced in 1996 and has increased household recycling rates from single-digit performance to more than 45 percent, and millions of tons of "residual waste" (that cannot be recovered higher in the waste hierarchy) is instead put to energy recovery–incinerated to generate electricity, thus reducing reliance on fossil fuels [18]. At first glance, the burning of waste may not seem aligned with a circular economy. However, for materials that cannot be put to a higher-order use through recycling, burning the waste is a better option than landfill. This is a transitional technology; as recycling continues to improve and renewable sources of energy increase in scope, the available waste to use in energy recovery will diminish.

Benefits for utilities

Even though the current digitalization and deregulation process does not yet focus on the circular economy, these measures have already led to energy and utility companies operating more sustainably. Examples are the extensive use of connected devices (e.g. sensors and meters in the field) and IT (e.g. for platform-based integration of a wide variety of applications such as billing for electric mobility) that both support more integration of renewable energy generation. These opportunities are already being tapped into and would be expanded on in the future. Projects with the following focal points are to be expected (depending on market and regulatory pressures):

- Smart metering will enable customers to actively save energy and reduce CO2 emissions and costs.
- "Lumen as a Service" for municipalities to control street lighting according to demand will save money and protect the environment.
- Through fine-granular real-time monitoring, grid operators will be able to control connected generators and loads individually and more precisely, and thus manage their grid much more accurately. This would allow more distributed and CO2-free renewable energy to be fed into the grid.
- Intelligent energy dispatching will make it possible to reduce technical grid losses. This is because shorter distances from the point of generation to the point of consumption mean reduced grid losses. Electricity generated in the neighborhood is then used directly in the neighborhood as much as possible. If these principles are applied, grid expansion can be optimized, and natural resources will be conserved.
- Predictive and prescriptive asset management using OT, IT, engineering and weather data will improve advanced fault diagnosis, enhance network agility to respond to fluctuating demands and optimize asset lifecycle. For example, asset and environmental data will be used to determine health indices and future performance forecasts for network equipment and components such as transformers and switchgear. These insights will enable one to make informed decisions accurately regarding when equipments should be maintained or replaced.
- Real time remote monitoring of asset health indices will allow engineers to take quick actions when assets are operating outside of their normal service levels. Service level management will help uncover the root cause of asset failures and take appropriate actions to reduce the hidden health deterioration of network assets, save energy and reduce GHG emission.

To consider the necessary elements of the circular economy, they must first be defined as strategic goals and then integrated into the corporate strategy. This could include goals such as:

- Sustainability for all goods, services, and energy use throughout the entire lifecycle.
- Smarter and Resilient Infrastructure, e.g. using intelligent links between production and consumers so that they are as resource efficient as possible.
- Transparent Supply Chains and Intelligent Operations for enabling better insights, self-prescribing improvements and covering the entire lifecycle of all equipment and goods used (e.g. smart meters, transformers, switchgear).
- Addressing climate risk and defining plans for sustainable development.

These strategic goals must be mapped into courses of action for day-to-day business. Examples include:

- Prevent and avoid waste by introducing the "Repairable by Design" rule.
- Ensuring the use of items for as long as possible, e.g. through timely and preventive maintenance based on predicted performance.
- Ensuring the reuse of items, e.g., by cleaning, refurbishing, and inspecting end-of-life equipment and spare parts, or by passing them on to other users through trading platforms.
- The recycling and conversion of waste into new materials, such as the conversion of vegetation management into mulch or the low-emission incineration and feed-in of the energy generated.
- Ensuring transparency of the measures in all work steps in order to continuously improve instructions for action and provide information to regulatory authorities.

Many examples from the energy and utility industry already show that a circular economy is not only resource-saving, but also economical. The business case will improve continuously if CO2 levies are introduced, as is being considered by many countries.

Path forward

The energy and utility industry can play a role in the circular economy by influencing and executing energy supply, transport, distribution, consumption, and management in a resource-saving way. In doing so they would:

- create incentives for customers to save energy (reducing or shifting consumption over time),
- enable the feed-in and management of renewable energies and are also able to manage the constantly increasing fluctuation in the grid,
- enable and manage flexibilities even across sectors, such as power to hydrogen or power to heat and cold air,
- provide “mobile energy” at charging stations in public spaces or privately for electric vehicles.

Utilities operate and use infrastructure consisting of a variety of interconnected components, such as transformers, switchgear, poles, wires, and an ever-increasing number of batteries on the grid as well as for energy storage in homes. All these components can and should be subject to the circular economy. This becomes even more important given electrification is predicted to increase sharply worldwide by 2050 [3].

The use of batteries for EVs and large-scale energy storage, which electric utilities will play a key role in, is predicted to grow significantly. Therefore, their participation as well as the participation of the auto manufactures, utilities and grid operators in the circular economy is essential, given batteries’ resource footprint and these different contributors roles in the battery lifecycle. Batteries consist of a variety of different raw materials, such as lithium, and follow a complicated and energy-intensive manufacturing process. Thus, managing the lifecycle is critical to their participation in a sustainable ecosystem. Here are a few ways to make the circular management of in-service batteries in the power grid sustainable:

- By utilizing modern technology, batteries can be accurately controlled to charge and discharge in an optimal way to ensure the balance between product life and performance.
- Use the right battery for the right application. Batteries for EVs have to be lightweight and thus lithium is typically the best option given today’s available technology. For other applications, such as stationary grid-scale energy storage, weight is not as important a parameter. Thus, other battery chemistries could prove to be better suited for certain applications as well as be more environment friendly.
- Batteries should be fully integrated into the supply chain so that alternative uses and replacements can be managed to ensure optimal performance during their lifetimes.
- Batteries can be replaced as their performance declines and offered for other uses on trading platforms. This would increase their rate of reusability.
- Batteries that are past their usable work life can be sent for recycling, refurbishment, or disposal via the same trading platforms. Batteries should always be designed such that they can be dismantled into their components as easily and as energy-efficiently as possible.

To make this possible, manufacturers should have access to battery operating data from the utility, charging network or organization using the battery to provide power to the grid. In this way, they can ensure that the design of future generations of batteries is further improved. At the same time, the obligation to recycle can be imposed on them.

The circular economy can also work to increase the sustainability and improve lifecycle management for other assets used by energy and utility companies, such as transformers, circuit breakers, switchgear, poles, and power lines. Thus, utilities should become active participants in the circular economy for batteries and their other physical assets.

This conversion cannot be taken for granted and requires investments and a stable framework by the legislator. Incentive-based regulations, as already established in many countries, can and should be expanded, and give the circular economy the necessary investments.

The necessary technologies for control, implementation and optimization are already in place:

- IoT devices and telecommunications technology for ongoing monitoring and management of deployed asset elements,
- Asset management systems to capture asset element master and transaction data relevant to the circular economy,
- Blockchain technology to provide data quickly and securely to authorized organizations, as well as to manage supply chains and trace back in case of problems,

– Open data models (such as those supported by the Open Data Initiative) which follows industry standards and open communication protocols such as MQTT for effective information exchange,
– Artificial intelligence and quantum computing to calculate new battery technologies and designs and, in conjunction with blockchain, optimize energy generation, load and pricing on a regional basis as well as optimize supply chains and workflows by analyzing and suggesting improvements,
– Secure, hybrid platforms to integrate stakeholder ecosystems.

As a global technology company, IBM provides, implements, and operates such solutions for clients in the energy industry as well as others. IBM helps address the circular economy and leverage the experience from different industries. Here are a few selected IBM products and solutions:

– The IBM Maximo® Application Suite asset management solution to optimize the operation of assets and asset elements. It uses AI, IoT and analyzes conditions to optimize performance, extend asset lifecycles and reduce operational downtime and costs. [19]
– The Environmental Intelligence Suite, a platform specifically designed for massive geospatial-spatial-temporal (maps, satellites, weather, drones, IoT) query and analysis services. [20]
– The IBM Flex Platform, a flexibility management solution to keep power grids in balance. As the pool of flexible energy grows, this will eventually allow more and more reserve power plants to be taken off the grid. This will replace mostly old fossil-fuel power plant technology with intelligent, more efficient balancing of supply and demand. [21]
– The Weather Company®, to provide advanced weather science with accurate forecasting and technology products to support smarter decision-making for business. [22]
– The IBM Blockchain™ Platform, to transform the way industries work using IBM Blockchain. [23] [24]

These solutions are just the beginning of what IBM can do in this space. IBM welcomes the opportunity to solve these and other challenges our clients face concerning the circular economy. We are working on more products and solutions and understand there is a significant and growing need for a trusted technology and strategy partner in this space. IBM is that partner. We recognize the need for the energy and utilities industry as well as others to embrace the technologies highlighted above to enable their participation and success in the circular economy. And by doing so, we will solve some of the world's biggest challenges together.

The energy and utilities industry will play a larger and increasingly important role in the circular economy from multiple aspects, as was elaborated above. While this introductory paper can only scratch the surface of some of these aspects, we recommend for upcoming discussions and papers to investigate the following directions: electrification and supply chain challenges, new materials research and relevance for energy and utilities, the need for new computing or infrastructure like Quantum to address systemic challenges. Finally, as this paper also highlights, circularity and the circular economy is of relevance to energy and utilities as well as many other industries and cross-industry collaboration will be beneficial if not necessary.

To learn more about IBM's commitment to participating in the development of the Circular Economy, please visit our website and explore our research and solutions: http://www.ibm.com/Sustainability

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