



Digital Growth Trends for Renewable Energy

"Digital is the new currency for Renewable Energy and we believe asset data analytics will transform our business model."

Jérôme Péresse
President & CEO
GE Renewable Energy

Summary



The renewable energy industry is undergoing a paradigm shift as more utility-scale wind and solar reach grid parity by driving lower cost curves and providing alternative energy options to traditional energy generation sources. Regardless of the political environment, renewables will grow as these resources become economically competitive even in the absence of government subsidies.

Industry leaders must embrace digitization to thrive in this rapidly evolving landscape—as a primary source of value creation and competitive advantage and as a disruptive force reshaping business models—or risk losing their market position to more innovative rivals.

This paper outlines three digital trends driving transformative change that every renewable energy executive should understand and plan for in the year to come.

1. Analytics drives everything

The new wave of dominant technologies—analytics, big data, mobile, cloud, the Internet of Things (IoT), and smart machines—are disrupting every industry. Renewable energy and the Industrial Internet of Things (IIoT) are unusually data intensive even by today’s data-rich standards, producing a magnitude of data not always seen by other industries.

For example, there are hundreds of sensors on every wind turbine that produce a stream of thousands of data points every minute. This massive amount of data is analyzed

to drive asset performance intelligence and predictive maintenance, taking into account variables such as market data, maintenance data, and the data streams for an entire wind farm or fleet.

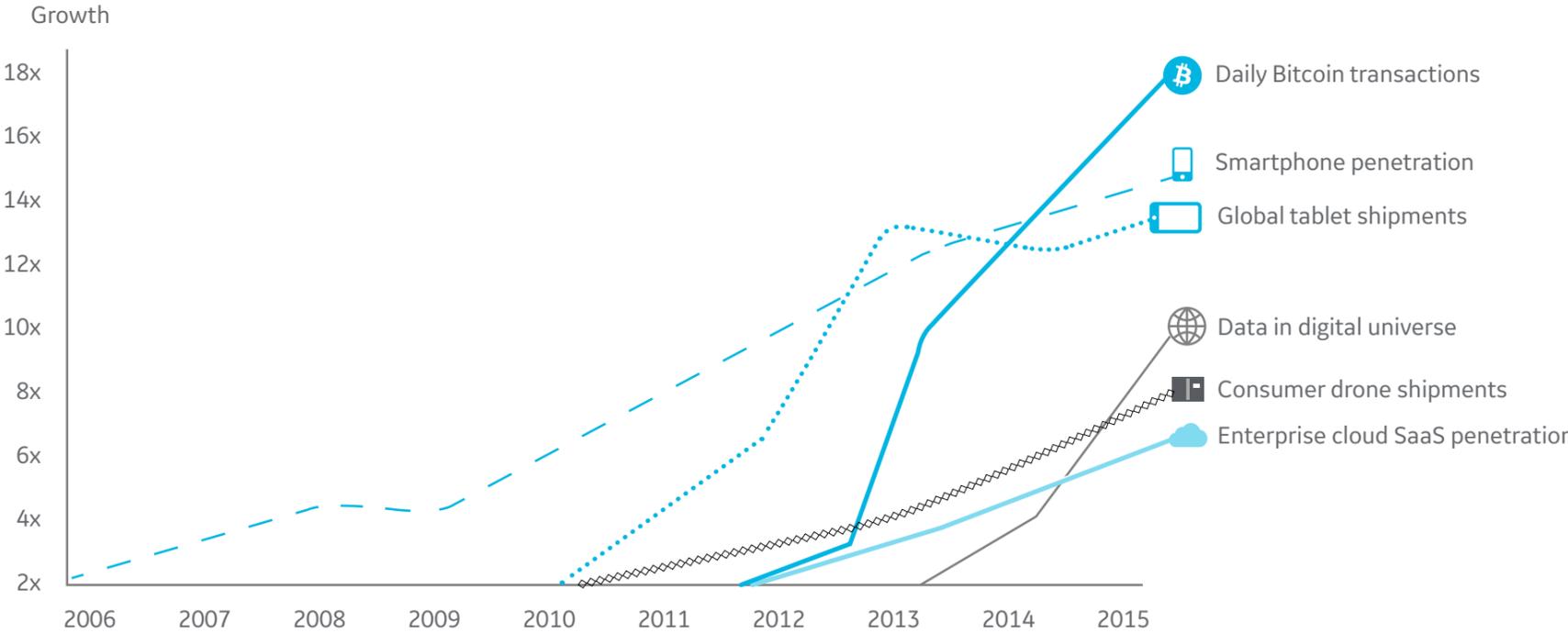
When advanced analytics are combined with learning algorithms, the insights and prescriptive recommendations that industrial data produces—generate value that can be leveraged for new business opportunities. At GE, we apply artificial intelligence (AI) and machine learning to drive sophisticated decision models to understand our machines with respect to their usage and conditional behavior, and predict potential outcomes with optimization guidance.

Predix, the platform for the Industrial Internet, connects physical and digital worlds so that industrial companies can transform the way they do business. Predix helps develop digital models of physical assets, called digital twins, that combine deep learning algorithms with real-time and historical machine behavior data to enable insights and actions, thus further driving revenue and operational efficiencies. Renewable energy leverages Digital Twin models for wind, hydro, and solar assets and components, along with our suite of Brilliant Manufacturing solutions, to build a smart energy ecosystem.

Recent technology adoption:

Technology growth in recent years

As multiple of starting year (1x)



Sources: Bi Intelligence, KPCB, Blockchain.info, NorthBridge Equity Partners, Capgemini



2. Cloud + edge is the next digital imperative

For a long time, technology has been a wallflower in the power and utility industry. But with the advent of decarbonization and consumerization, the adoption of innovative technologies becomes crucial. Cloud-based technology solutions have disrupted most industries, and companies operating within the electricity value chain are being pressured to embrace the cloud revolution as they consolidate, manage, and analyze volumes of dynamic and time-series machine data generated by renewable energy sources.

With increasing demand for renewable energy coming online, operators are racing to leverage data and analytics to improve

energy production, reliability, and availability. The competitive advantage that cloud and edge computing offer will eclipse the limitations of legacy systems integrations. GE's Edge technology brings Predix computations to the asset for real-time machine response, thus driving the highest level of asset optimization.

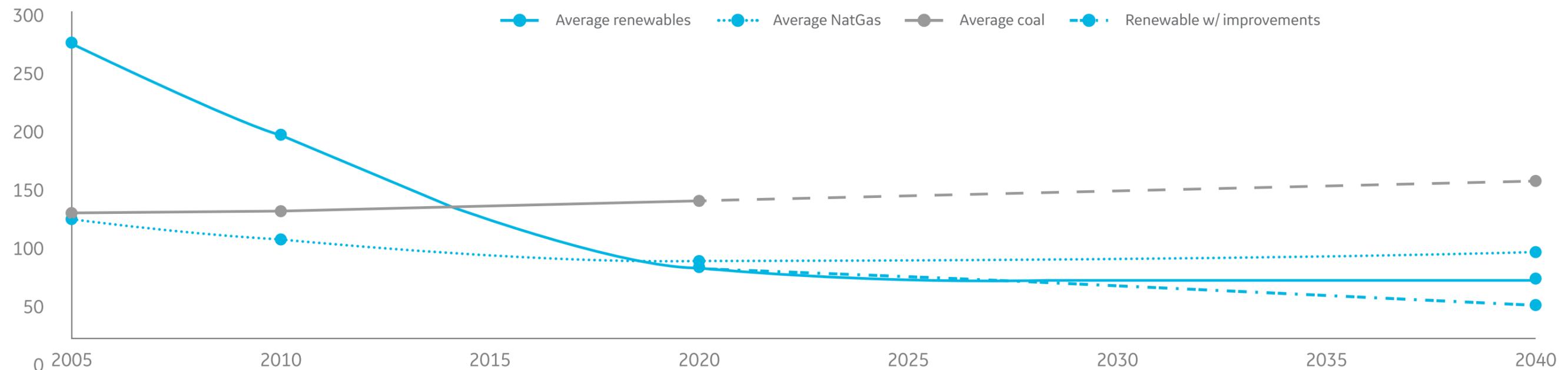
Key value drivers for cloud and edge computing include:

- **Performance.** By placing data collection, transmission, and analytics at the edge more intelligent algorithms can be run closer to the machines, resulting in optimized performance.
- **Speed.** The cloud provides faster time to implementation, innovation, and third-party services and applications.

- **End-to-end security.** Systems are built to be secure from the ground up and to be easily updated.
- **Lower costs.** Avoids capital investments, lowers total cost of ownership (TCO) and has better opportunity costs.
- **Ability to scale.** A cloud service delivery model makes it easy, fast, and reliable to scale.
- **Global visibility.** Data can be aggregated and analyzed across geographies and assets in real-time.
- **Reliability.** Cloud-based microservices mean that any failures are isolated in the cloud unlike monolithic systems with vulnerable and complex dependencies for the entire system.

Cost curves

\$ / MWh



Source: GE analysis based on data from Lazard Levelized Cost of Energy Analysis, historical versions, published from 2005 to 2015 and NREL Past & Future Cost of Wind Energy Report, published 2012.

3. New business models

Renewable energy and digitization are two of the leading catalysts for the transformational change sweeping through the power industry. Together with distributed generation, smart grids, and storage, they are spurring innovation and fueling the rapid rise of innovative business models.

According to recent CEO survey, renewable energy adoption is the biggest threat and opportunity for power and utilities organizations. Currently, the renewable industry is already operating successfully with centralized models (wind, hydro, geothermal, and utility scale solar) and emerging models of distributed generation (community wind and rooftop solar). New business models will revolve around data monetization and outcome-based revenue models.

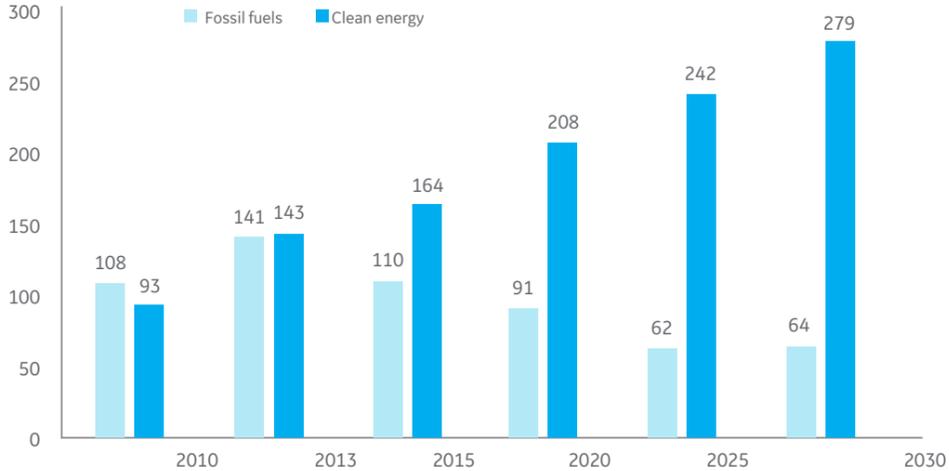
Digitization is leveraging the power of data and advanced analytics to improve energy production and efficiency while also unleashing latent value. For example, GE's Digital Wind Farm can boost energy production by up to 10% and could help generate an estimated \$5 billion of value for the wind industry.

Data monetization is redefining the power industry by opening up new opportunities, such as platform and shared economy, where digital assets are produced, transacted, and consumed across rapidly expanding ecosystems of technologies, enterprises, developers, and services. The phenomena that started with technology companies like Google, Amazon, and Facebook, will spread to the entire electricity value chain (generation, transmission, distribution, and consumption).



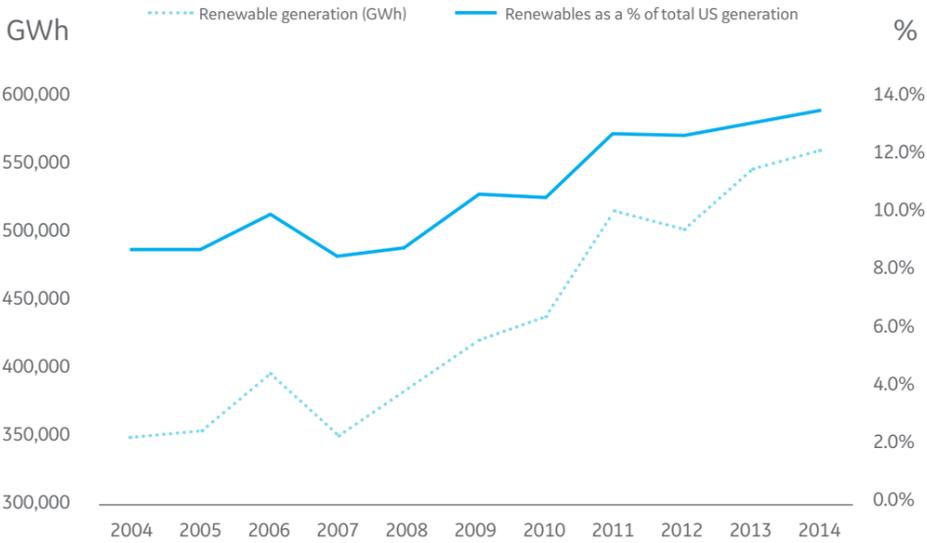
Fossil fuels and renewable power generation

Global additional power generation capacity (in GW), 2010 to 2030



Sources: BNEF, New Climate Economy Values beyond 2013 are estimates

Renewables leading the transition



Sources: EIA, LBNL, SEIA/GTM, US Department of Energy. Includes generation from CSP and grid-connected PV; assumes a 25% capacity factor for CSP and an 18% capacity factor for PV

Traditionally, power and utility companies have leveraged CAPEX models to transact with customers. Digital solutions are creating a new outcome-based revenue model for renewable energy, in which the monetization of products and services is realized based upon the additional value that digital solutions provide to customers. This creates a paradigm shift in revenue recognition models and drives a significant upside for sellers and buyers while creating data-driven competitive advantages for early adopters.

At GE, we are exploring new business models that leverage data insights powered by Predix while co-creating innovative digital solutions with our customers. Our Renewable Digital Solutions allows customers and a community of 20,000 developers to co-develop customized applications that address specific industrial challenges. Our platform spurs innovation and encourages collaboration between industry participants working to solve the same or similar problems. This enables the sharing of talent, resources, and knowledge, making it faster and cheaper to innovate and deliver new capabilities.

The renewable energy industry is moving toward digital at a rapid pace. Companies who embrace digital industrial transformation will thrive by generating the greatest value and positioning themselves to not only succeed in a changing industry, but to define it.

For more information on our Renewable Energy Solutions, please visit www.renew.ge/digital.





About GE

GE (NYSE: GE) is the world's Digital Industrial Company, transforming industry with software-defined machines and solutions that are connected, responsive and predictive. GE is organized around a global exchange of knowledge, the "GE Store," through which each business shares and accesses the same technology, markets, structure and intellect. Each invention further fuels innovation and application across our industrial sectors. With people, services, technology and scale, GE delivers better outcomes for customers by speaking the language of industry.

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