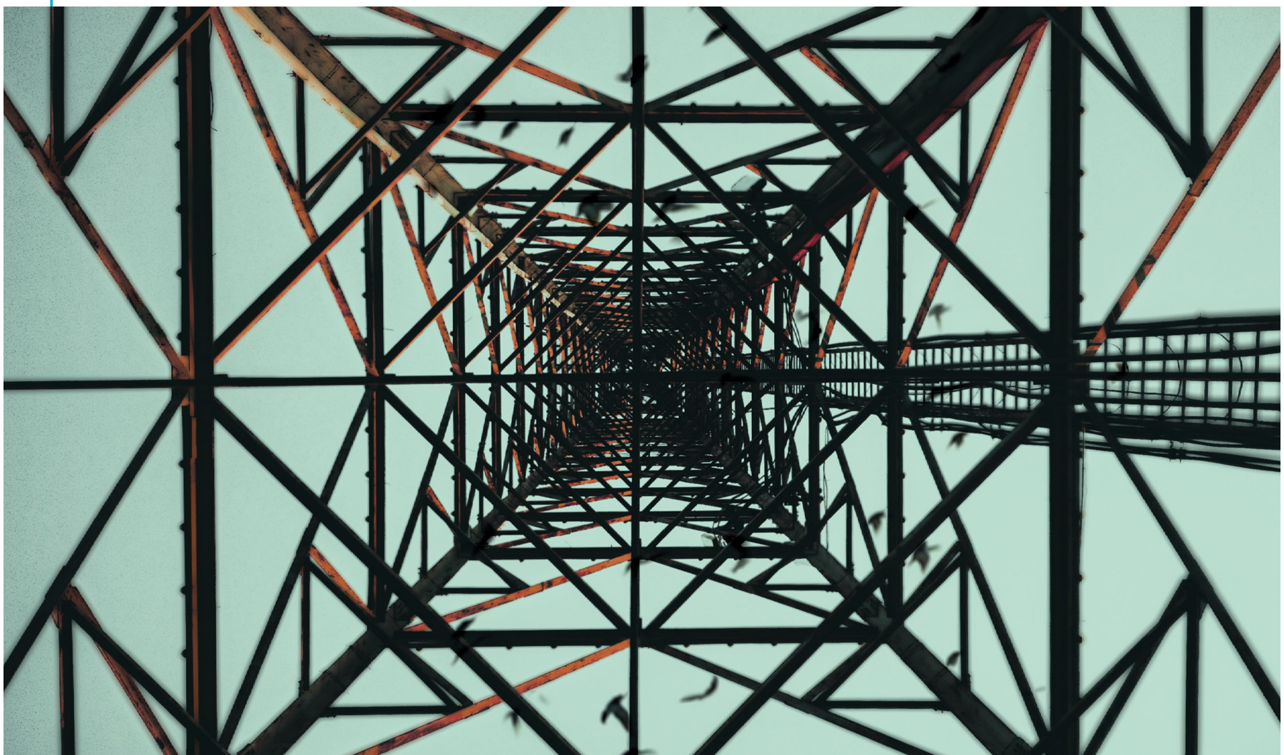

IAC Landscape Report

Smart Grid

Progress in power systems towards 'Net Zero Emissions' goal

A look through patent data

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About Innovation Asset Collective

Innovation Asset Collective (IAC) is an independent membership based not-for-profit selected by the Canadian Government's Department of Innovation, Science and Economic Development (ISED) to assist Canadian small and medium-sized enterprises (SMEs) in the data-driven clean technology sector with their IP needs.

Led by experts in IP education, strategic counsel, IP generation and patent access, IAC helps Canadian SMEs understand and harness the value and power of their IP so that their innovations can be commercialized and protected for the benefit of the Canadian economy.

With the help of the IAC team, member companies will maximize the value of their intangible assets, while benefiting from the services of the collective and setting the stage for international growth. By realizing the inherent value of IP, IAC will foster Canadian innovation, which will see more Canadian companies succeed globally.

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About the landscape report

Recent technological developments and trends in the energy sector are dominantly layered with sustainability goals and the use of renewable sources of energy. Innovation in smart grid and energy storage systems is making it possible to envisage immediate small-scale impacts for reducing carbon footprint and support a long-term sustainable energy future. IAC team examines research and development (R&D) trends in smart grid by observing related patenting and market activities.

Modernization of the electricity grid builds on the carbon neutrality agenda by integrating distributed energy resources (DERs), facilitating the incorporation of cleaner sources of generation and other cost-effective measures. Next-generation electricity grids, often called smart grids, leverage advanced power electronics, grid sensors, and digitization to enable bi-directional communication and energy flow and automation of transmission and distribution. These improvements allow grids to become more resilient and flexible to demand fluctuations.

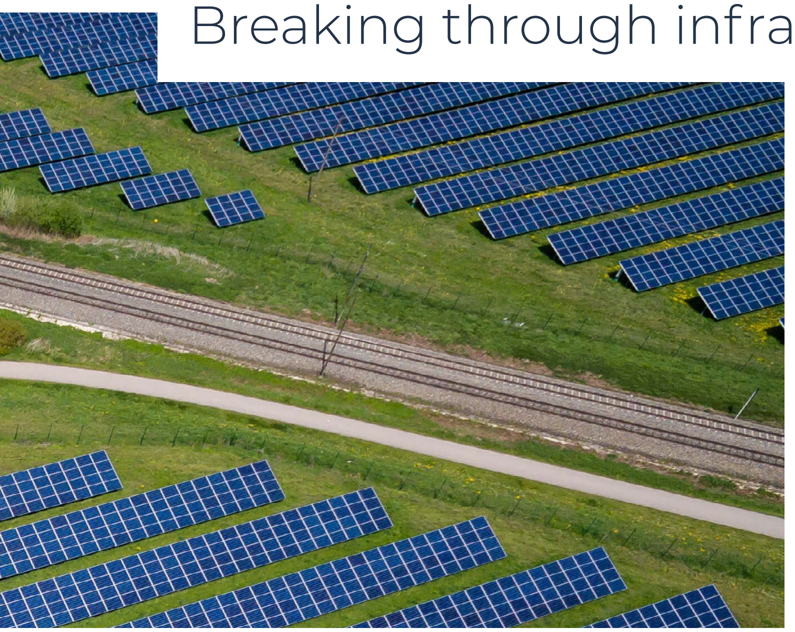
This landscape study breaks down the smart grid's value chain at the distribution end to elucidate the activities and development in modernizing distribution networks, emerging retail side, and changing customer end. The value chain identifies technology segments that illustrate the assemblage of technologies needed to deliver essential functionality of a smart grid, i.e., grid management, integration of distributed energy resources (DERs), and advanced metering infrastructure (AMI). The value chain illustration further links organizations' commercial activities and technology segments.

The primary data source for this study is patents. This data is supplemented with industry-related information, including public policy changes, market activities such as mergers and acquisitions (M&A), licensing deals, alliances, and key projects undertaken. A summary of the landscape report is provided below. The detailed landscape report captures granular details of the competitive landscape as observed through worldwide patenting strategies and identifies any risk and opportunities through market insights and white-spaces in technology segments in the smart grid sector at large.

How can landscape reports help businesses?

Patent landscape reports are one way to leverage knowledge trapped in IP assets. Divergent insights can be drawn by shifting the focal point of analysis from technology to organizations. For businesses attempting to create a multi-year technology strategy, landscape reports can provide technology trends, discontinuities, organizations' growing dominance and emergence, and new market opportunities.

Carbon neutrality:
Breaking through infrastructural inertia



Visible environmental impacts of traditional sources of energy generation and continuously growing demand due to urbanization and industrialization have put the energy sector at the center stage of climate change discussions. Governments around the world are framing policies and adopting de-carbonization strategies to support and forward the 'carbon neutrality' agenda to achieve net-zero emissions by 2050[1].

Energy generation and distribution and energy usage form two critical aspects to evaluate the role of energy sector in carbon neutrality. Energy usage drives the efficiencies with which the systems can utilize the received power and, in turn, is a measure of energy loss. Simple techniques, such as making buildings and appliances more energy efficient, can reduce the overall energy demand. On the other hand, energy generation and distribution refer to the utility systems engaged in the generation and distribution of power to a variety of load centers, including buildings and appliances. The two aspects required to meet a secure and sustainable energy future rely on greater use of renewable sources of energy and energy efficiency.

Due to financial and infrastructural limitations, the pace and scale of innovation adoption in the power sector are gradual and require bolstering through guided sectoral policies. The Canadian government's position on climate change includes the introduction of minimum carbon-pricing standards[2] for provinces in order to manage renewable sources and reduce greenhouse gases (GHGs) emissions is one such example. In Canada, though fossil fuels maintain a dominant share in energy generation, efforts to bring a shift towards clean energy generation can be seen in the public sector's commitment to carbon neutrality, investments in upgrading infrastructure with newer and smarter technologies, and advancements in energy storage technologies (e.g., Ontario Power Generation[3], Hydro-Québec[4], SaskPower[5], BC Hydro[6]).

International Energy Agency (IEA), an intergovernmental organization providing statistical information on the global energy consumption and policy recommendations, forecasts a drop in investments in non-renewable sources (i.e., coal, gas, oil and nuclear) and an increase in the investments in renewable sources of energy[7]. This drop may be due to lower cost, flexible and effective operation of clean generation technologies compared to setting up a new natural gas plant.

Grid modernization is generating more rapid sectoral transformation at the distribution end of the utility, creating new economies and new market opportunities. Transactive energy and digital management of DERs are the future arenas of energy. Many recent smart grid initiatives are a product of the public sector pressure on utilities to modernize grids and the low barriers for small- and medium- sized businesses to offer digital solutions.

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[1] United Nations Framework Convention on Climate Change (UNFCCC), The Paris agreement 2015 on climate change, https://unfccc.int/process-and-meetings/the-paris-agreement/the-paris-agreement

[2] The Globe and Mail, Mar 2021, Canada's carbon tax is constitutional, Supreme Court rules, https://www.theglobeandmail.com/canada/article-canadas-carbon-tax-is-constitutional-supreme-court-rules/

[3] Ontario Power Generation, Nov 2020, OPG commits to being a net-zero company by 2040, https://www.opg.com/media_releases/opg-commits-to-being-a-net-zero-company-by-2040/

[4] Hydro Québec, Electricity supply plan 2019-2029, https://www.hydroquebec.com/electricity-purchases-quebec/supply-plan.html

[5] SaskPower, Smart meters: Building a modern power grid, https://www.saskpower.com/Our-Power-Future/Powering-2030/Smart-Meters/Building-a-Modern-Power-Grid

[6] BC Hydro, Net metering program, https://www.bchydro.com/work-with-us/selling-clean-energy/net-metering.html

[7] International Energy Agency (IEA), Oct 2020, World Energy Outlook 2020, https://www.iea.org/reports/world-energy-outlook-2020.

Clean energy transitioning: A shift from centralized to distributed generation

Future energy solutions should include both reliability and sustainability as essential embodiments of utility systems. The next generation of power grids and distribution stations are adapting to incorporate these features through the integration of alternative sources of energy, also known as DERs (and include both distributed generation and storage systems). Particularly, storage solutions' ability to store energy for a long period of time and make it available when needed enables utilities to accommodate the intermittent nature of some renewable energy sources.

However, diversified and distributed power supply units increase the complexity of a grid and make it harder to coordinate to maintain steady state and quality of the power. To address the added complexity, smart grids make use of advancements in technologies to offer flexibility to grid operation needed to integrate DERs.

The International Energy Agency (IEA) defines 'smart grid' as:

"A smart grid is an electricity network system that uses digital technology to monitor and manage the transport of electricity from all generation sources to meet the varying electricity demands of end users. Such grids are able to co-ordinate the needs and capabilities of all generators, grid operators, end users and electricity market stakeholders in such a way that they can optimise asset utilisation and operation and, in the process, minimise both costs and environmental impacts while maintaining system reliability, resilience and stability."

Source: IEA (2015), Technology Roadmap: Smart Grids, OECD/IEA, Paris.

Smart grid: Essential components in changing topologies

Traditional energy grids utilize unidirectional transmission and distribution systems and dispatch generation primarily by relying on a central unit. Grid modernization efforts are revolutionizing how utilities distribute power to consumers and how consumers interact and control their energy consumption. Recent advancements in distributed generation and energy storage technologies and accelerated growth in grid management technologies are making it possible to host more than one energy supply on a utility. The next generation of smart grids is starting to integrate DERs in order to improve grid flexibility and resiliency. This involves forecasting the generation and availability of alternative energy supply sources and managing the schedule and dispatch of energy from multiple (and diverse) energy sources. Notably, the complexity is not just added on the supply side; new developments in electric vehicle (EV), home automation systems, building management and consumers turning prosumers require far more sophisticated systems to manage the demand-side resources as well.

A smart grid overcomes supply and demand side complexities through a modernization effort entailing renewed grid automation, control and visualization devices utilizing intelligent electronic devices, automated regulators, grid sensors, and synchrophasors. The modernization requires revamping grid management infrastructure as well as systems and software used to observe, exchange, manage and control grid feeder lines and supply sources. As we understand, a smart grid's central functionality is in the management of diverse assets connected to a utility to deliver reliable and quality power to consumers.

Additionally, the possibility to host distributed and diversified sources of generation to supplement utility capacity and respond more efficiently to fluctuations in demand has given rise to retail electricity models. Opening of electricity marketplace for DERs generates possibilities for third party small producers to transact energy, bringing in flexibility in electricity rate models and variable pricing for consumers. Participation in demand response programs, new pricing models to utilize cleaner electricity when available, or shifting load based on time-of-use, are a few examples of energy consumption schemes and load management. These complex interactions are possible only when an

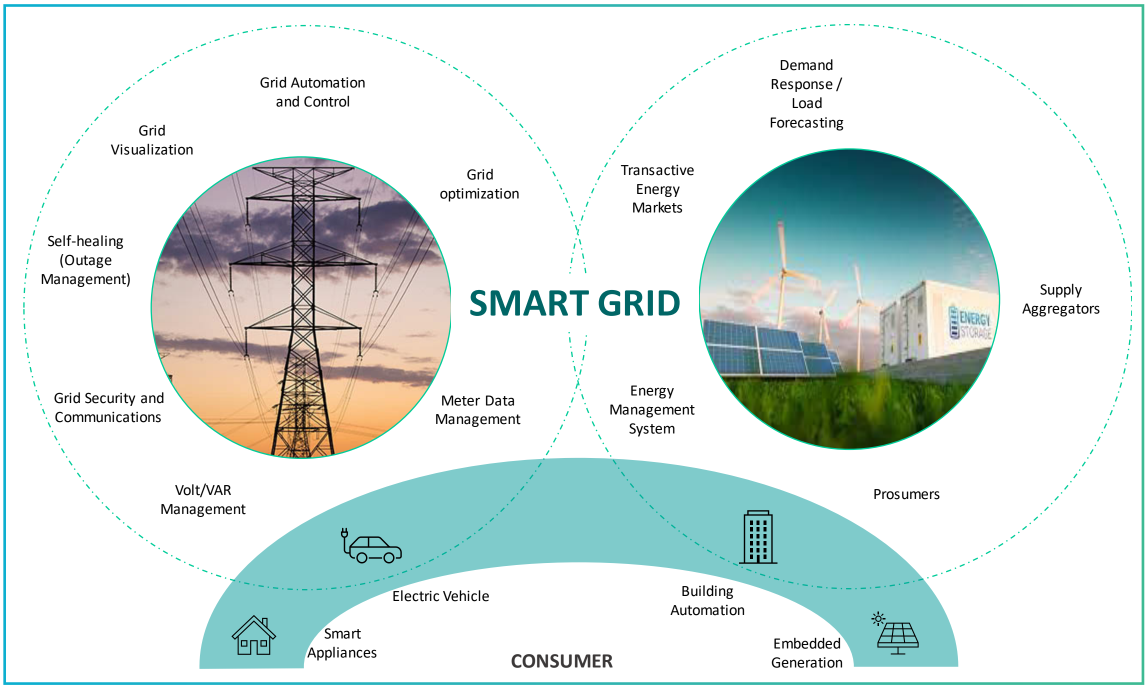

Fig I. Smart Grid Distribution Network

interactive way to exchange data between the utility, retail, and consumers exists. This is provided by advanced metering infrastructure (AMI) and the utility's use of advanced distribution management systems (ADMS). Jointly, technologies required to integrate DERs (i.e. distributed energy management systems, DERMS) and perform advanced metering data collection and management enable the three ends of a distribution network (distribution station, the retail side and consumer end) to function together.

Figure I. summarizes the various functions being performed at different ends of a distribution network of a smart grid.

Figure II illustrates the smart grid value chain that is used in the report to link organizations' commercial activities and technology segments. This formed the basis for patent data collection and analysis.

	DISTRIBUTION		RETAIL	CONSUMER
Composition	➢ Integration of distributed energy resources (DERs) ➢ Increased levels of visualization, automation, and control		➢ Increased customer interaction ➢ Data driven products and services ➢ Newer pricing models, electricity marketplace	➢ Greater engagement ➢ Utility alternative pricing and rate options ➢ Become prosumers
Functions	Grid Management		Integration of DERs	Advanced Metering Infrastructure
Systems and Software	*Resource planning and grid optimization*	*Demand response and load management*	*Distributed energy management system*	*Meter data management system*
Infrastructure	*Grid automation and control*		*Microgrid*	*Smart meter*

Fig II. Smart Grid Value Chain

The detailed landscape report contains the following information:

- Value chain with key organizations placed in each technology segment (as shown in fig II)
- Risks and opportunities in the smart grid sector
- Multiple time-series illustrations to analyze patenting trends (including by technology segments, geographic location, top filers, technology cycle time (TCT)) and summaries of the innovation activities based on these illustrations
- Time-series competitive landscape illustrations (by benchmarking patent portfolios using generality and originality scores, portfolio value index) to elucidate changing competitive positioning of the companies in each technology segment over time

Summary of organizational activity

As anticipated, this landscape study reveals a predominance of filings originating from China with Chinese state-owned utility, State Grid Corporation of China, leading. Despite these aggressive filings, Chinese players have negligible patenting activity outside China, accounting for only ~4% of patents filed in other countries.

Under the thick layer of filing trends in China, the patenting strategies identified in the rest of the world reveal a few companies reappearing as top filers across smart grid technology segments. These include General Electric, Siemens, ABB, Hitachi, Toshiba, Sumitomo Group and Mitsubishi Group. Companies like Honeywell, AT&T, IBM, Kyocera and Panasonic are also prolific filers in smart grid. Companies like Schneider Electric, S&C Electric and LS Electric have strong portfolios in infrastructure. Besides these established companies, individual technology segments also reveal Itron and Hubbell to be well-positioned in smart meters and Bidgley in load disaggregation. Causam Energy, also engaged in building a strategic patent portfolio, has a strong commercial presence as well.

On the Canadian front, Opus One Solutions (offering metering solutions) is leading, with many small players taking measured steps to find their foothold in the emerging areas in smart grid. These include Peak Power, Enbala (acquired by Generac), Hatch, UWB energy, Bluewave-ai and Tantalus (also owns Energate).

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The detailed version of this, as well as future Patent Landscape Reports will be available to all IAC members. If you are a member and have any questions about these reports, please feel free to get in touch with Melissa Bouffard, Relationship Manager at mbourffard@ipcollective.ca

If you are a Canadian data-driven cleantech SME and are interested in joining IAC, for more information, please connect with Rasha Shamat, Business Development Manager at rshamat@ipcollective.ca.

We would also invite private or public organizations to connect with us at partner@ ipcollective.ca. If this is a topic of interest and to explore how we might be able to partner together to further the discussion of IP in the cleantech sector.