IERE Technology Foresight

Disruptive Technologies in the 2030s
Executive Summary

October 2023

FROST & SULLIVAN

This Technology Foresight 2023 is the third report of IERE's Technology Foresight activities. The technical research for the report was commissioned to Frost & Sullivan and was finalized with input from IERE's Technology Foresight Committee, member experts, and others.

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IERE is an organization for exchanging electricity and energy-related cutting-edge technologies and R&D information among its members from the electricity and energy supply industry, equipment provider businesses, academic research, government, etc. This unique platform is of great help to executives, senior managers, engineers, and researchers who are responsible for R&D and solutions. It is a worldwide, non-profit organization, established as "International Electric Research Exchange" in 1968.

Contents

Note: One hundred **File Cards** are included in the **Interim Report**.

Executive Summary

Background

In response to the increasing energy demands of a growing global population, global warming, and other issues, technologies are changing rapidly. They affect the conventional utility business models and operational and planning activities directly and indirectly. Some may even be disruptive. IERE has global and world-class expertise in envisioning, researching, developing, implementing, monitoring, and assessing such technologies. However, the needs, drivers, development, and adoption paces vary drastically amongst jurisdictions.

IERE studied 20 Emerging Technologies and five Fringe Technologies in 2017 and compiled them into a members-only deliverable as TF2017. Six years later, it is important to reflect on the results of these studies and, from a current perspective, to predict specific technologies that could be realized and have a significant social impact in the 2030s.

To this end, it is desirable not only to introduce the technologies in question but also to select and delve into technologies that are currently in the demonstration stage and have a high potential for realization with a truly disruptive impact from among those that are currently undergoing multiple projects.

Objectives

- Evaluate the impact of various emerging and innovative technologies currently under discussion on their practical application in the electric utility industry in the 2030s.
- Identify technologies with high impact and high feasibility across a wide range of business fields in which members are involved, a brief survey of 100 promising technologies that are not in the idea stage but in the demonstration stage toward practical application should first be conducted, with six technology categories (Figure 1) in mind.
- Provide an in-depth report on the Top 20 technologies selected from the list, by incorporating the opinions of IERE members, with input from experts to provide a concrete picture of the technology by detailing what disruptive impact the technology will have within the industry, what incentives are available to promote its realization, and what potential obstacles exist. This information will help define better business strategies.
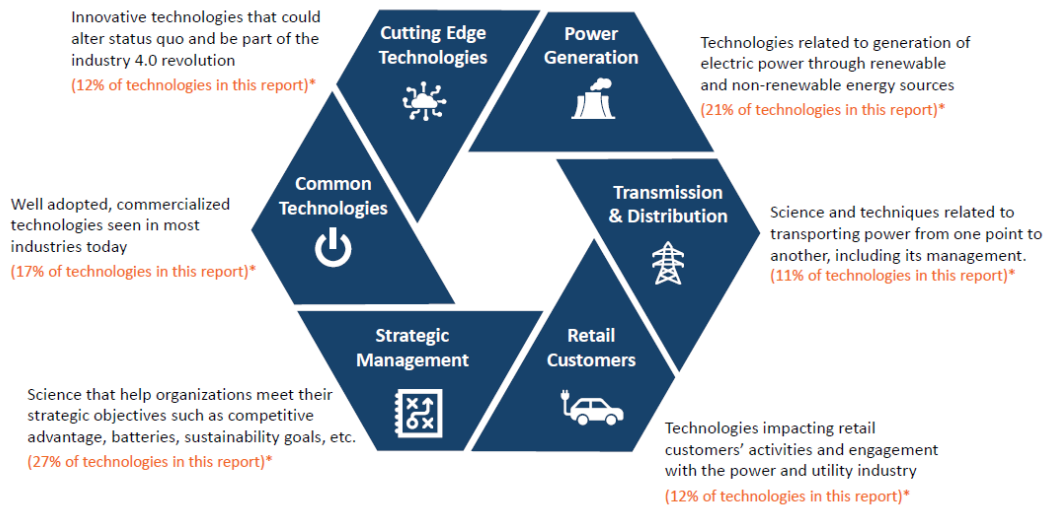
Figure 1 Selected six technology categories

Major Accomplishments

Figure 2 shows the work plan for the series of Technology Foresight activities. A survey of IERE members was also conducted for Part 1.
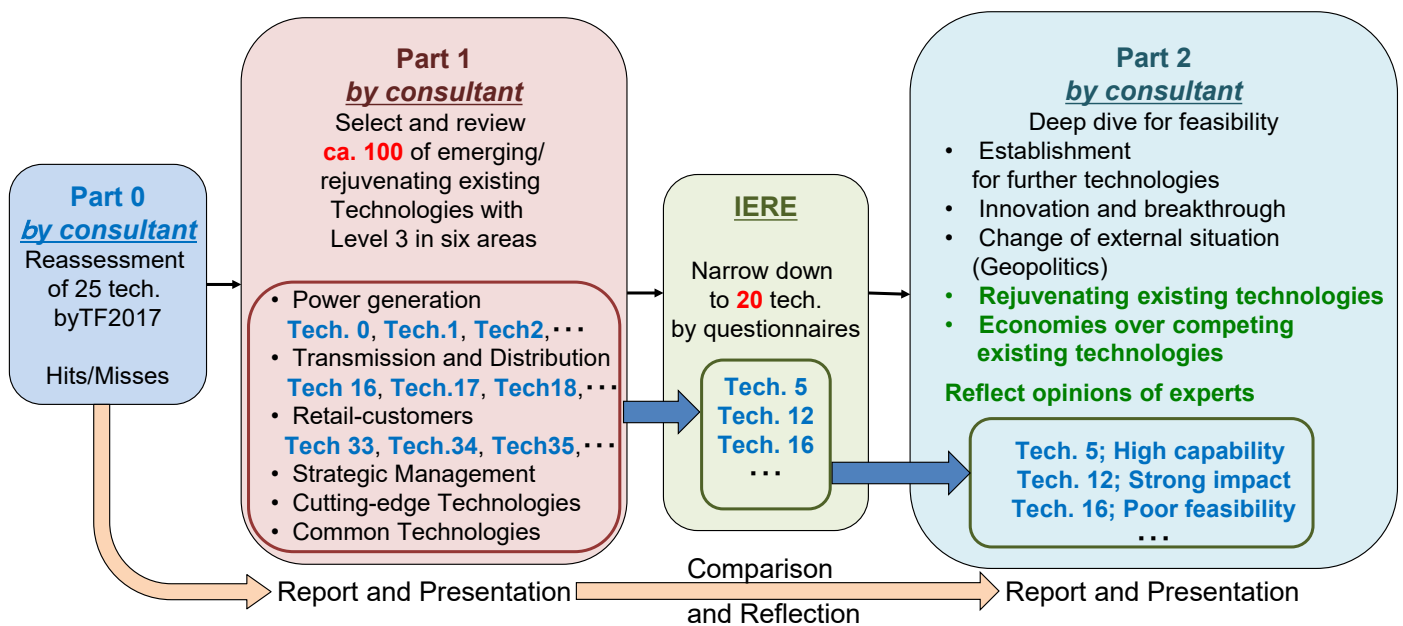
Figure 2 Work plan for TF2023 activities

(1) Assessment of past Technology Foresight (Part 0))

- Reconfirmed and briefly summarized the current trends of technologies identified as Emerging Technologies in past reports (TF2017, 2017).
- The current status of each technology was analyzed for each related item and compared and evaluated with the predicted results at the time. In addition, items that should have been selected at the time but were overlooked were summarized (Hits/Misses) (see the Interim Report for details).
- These evaluation activities will not only enhance the reliability of deliverables but will also be useful in optimizing current and future selection criteria and strengthening intellectual evaluation capabilities.
- This result was reflected in the technology selection in Parts 1 and 2, which were subsequently conducted.

(2) Extraction of emerging technologies and creation of file cards (Part 1)

- One hundred emerging/rejuvenated (re-emerging) technologies were selected (Appendix 2 and 3) and compiled as a file card, classified into six technology categories.
- Technology selection was conducted at the level of some subdivision where specific projects were being implemented, as illustrated in Figure 3, Level 3.
- In selecting the technologies, a long list of 193 technologies was compiled based on two surveys of IERE members and advice from Technology Foresight Committee (TFC), from which 100 technologies were narrowed down.
- File Cards containing the following items were created for 100 technologies (see the interim report for the specific content of each card):
  - Outline
  - Technology Readiness Level (TRL)
  - Human Readiness Level (HRL)
  - Economics
  - Regional Aspect
  - Impact on Electric Power Business
  - Impact on Society
  - Future Outlook
  - Development Entities
  - Projects
  - Other References

	Level 1	Level 2	Level 3	Projects
Renewable energy	Wind power	Offshore wind power	Floating type	Project A
			Blade recycling	Project B,C
	Solar generation	Next Generation Solar Cells	Organic film type	・・・
Energy storage	Secondary batteries	Lithium-ion batteries	All solid type	
Hydrogen	Hydrogen production	Carbon free hydrogen production	Natural Hydrogen	
New business	Measures against global warming		Biomass coal for carbon negative	
		TF2017	TF2023	

Figure 3 Examples of target technology granularity level for technology selection

(3) Narrowing down and deep dive into the top 20 technologies (Part 2)

- Based on a survey of IERE members and opinions from TFC, 20 technologies were selected (Table 1) and explored in depth from each of the six fields, and their feasibility was demonstrated.
- The items shown in each deep dive are as follows. In particular, a total of 40 views were received from more than 20 experts, including IERE members, and these were also included in the report:
  - Description
  - How it Works?
  - Why is the Technology Needed?
  - Drivers & Restrains
  - Potential for Market Transition
  - Technology Readiness Level
  - Social Readiness Level
  - Application and Timeline
  - Feasibility Report
  - Key Development Entities and Their Major Projects

- Regional Potential
- Overall Market Forecasts
- Experts' View
- Further Reading
- Incorporate the opinions of experts, including IERE members, especially with regard to a replacement from existing technology (infrastructure) and economic perspectives.

Table 1 Selected Top 20 Emerging Technologies

Business Fields	Selected Technologies
Power Generation	Floating Renewables
	Hydrogen Fueled Turbine
	Perovskite Solar Cells
	SMR & Safety Reactor
	Bio-Synthetic Natural Gas (Bio-SNG)
Transmission & Distribution	Grid Analytics
	Grid-Forming Inverters
	Intelligent Universal Transformers
	Low-to Medium Voltage DC Grid (DC Microgrid)
	Virtual Power Plant
Retail Customer	Emerging Heat Pump
	Integrating EV and Battery Energy Storage (V2X)
	Sensor Fusion
Strategic Management	Carbon Capture Technologies (BECCS & DACS)
	CCU Derive E-Fuel
	Green Hydrogen
	Repurposing Existing Pipelines for CO_2 and Hydrogen
Common Technologies	Prescriptive Analytics
	Solid State Batteries
Cutting Edge Technologies	Quantum Computing

Way Forward

The findings of this report underscore the importance of following action items for the power and utility companies that are necessary in the wake of aggressive climate actions and emerging computing capabilities. They are:

- **Build the necessary capabilities to cater to an exponentially growing electricity demand**
  The demand is expected to grow due to industrial electrification, EV adoption, and increased reliance on power-intensive computing machines such as AI and blockchain. AI-driven applications, such as ChatGPT, are predicted to consume 8–-21% of the global electricity supply by 2030, while EVs may account for as much as 4% of global electricity demand by 2030.
- **Facilitate the integration of renewables and distributed power generation in the energy mix**
  Renewables and distributed power generation are expected to contribute towards trends such as decarbonization and prosumerism.
- **Upgrade the energy infrastructure to make grids smarter, generate valuable data, and operate remotely**
  These features will enable safer and more efficient grids and generate better insights from consumer and grid data.
- **Invest in technologies to help reduce carbon footprint**
  Invest in technologies that can help reduce carbon footprint to not only meet regulatory requirements but also to gain goodwill from consumers and even generate positive returns.

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Rev. 1 Jan. 25, 2024
Oct. 16, 2023