IERE Technology Foresight 2020

Vancouver, Canada 17th May 2017

Presented by **John W. M. Cheng**

on behalf of IERE Technology Foresight Committee members
(**Tetsuo Matsumura, Friedrich Schulte, Hironobu Suzuki, Kevin East, Gaétan Lantagne, Greg Tosen, John W. M. Cheng, Takao Watanabe**)

IERE Technology Foresight 2020

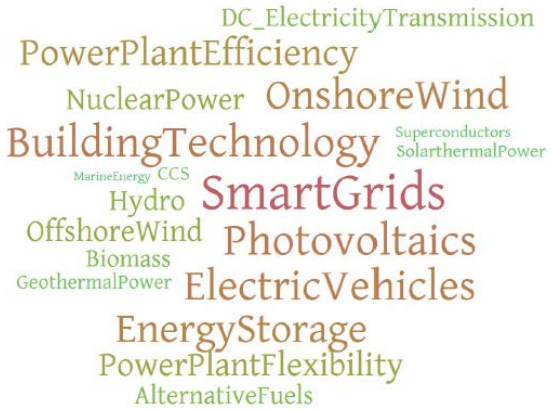
FROST & SULLIVAN

Background : IERE's Technology Leaders Meeting (TLM)

2015 IERE, Berlin

Key technologies

Which technologies are considered important?



A follow-up study could be launched to facilitate an in-depth analysis

- The group from this TLM could be a kernel to **prepare and launch an in-depth study** to deal with open questions more thoroughly. Beyond the active IERE member's contribution this exercise would probably need **external support and funding by IERE**
- This would enable an **external communication of results** and may also lead to **new approaches in tackling development hurdles** by joint R&D effort
- **Opportunities for collaboration** could be pointed out clearly. **Future business opportunities** could be identified

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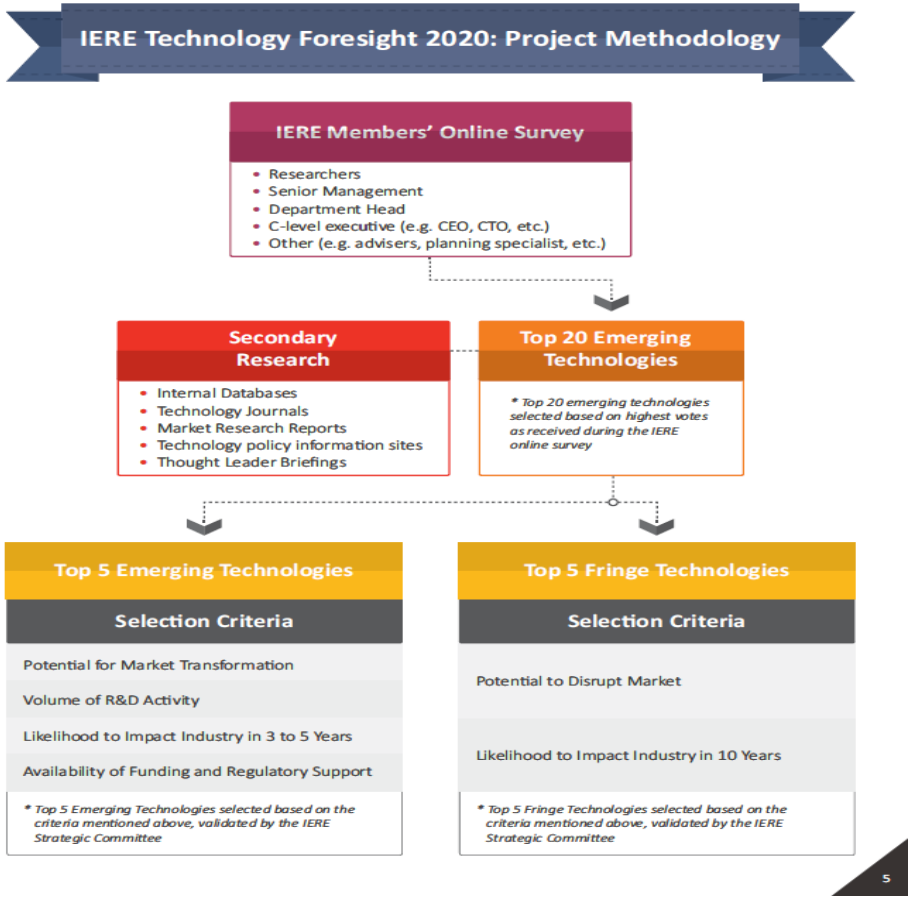
Methodologies, Selection Criteria and Key Attributes of Each Technology



Key Attributes per technology

- Function
- Industry challenges
- How it works
- Advantages & disadvantages
- Enablers and barriers
- Potential for market transformation
- Technology Status
- Economics
- Alternative/competing technologies
- R&D Objectives
- Key organizations
- Key developments
- Regional market trends
- Global market potential & forecast (201
- Future Outlook
- For Further Reading

2016 IERE & Frost & Sullivan

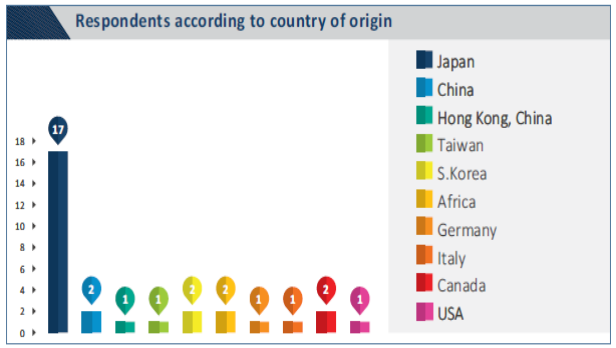
IERE Technology Foresight 2020

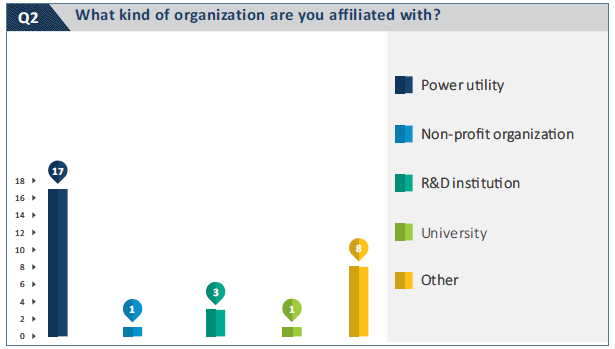
IERE Technology Foresight 2020 was first presented at IERE-CLPRI workshop in Hong Kong, November 2016

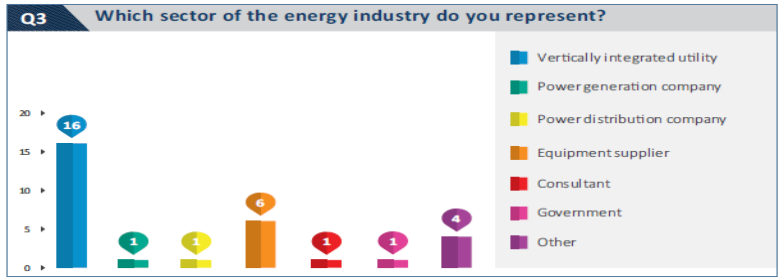
2016 IERE-CLPRI Workshop, Hong Kong

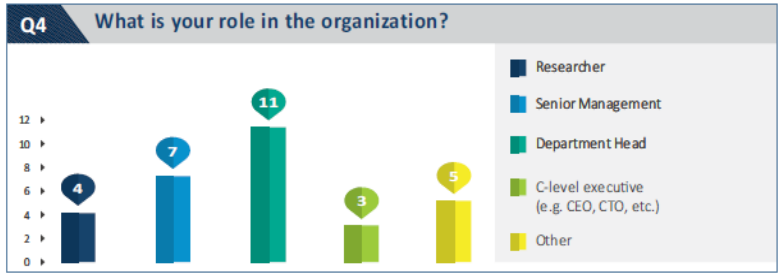
IERE Technology Foresight 2020

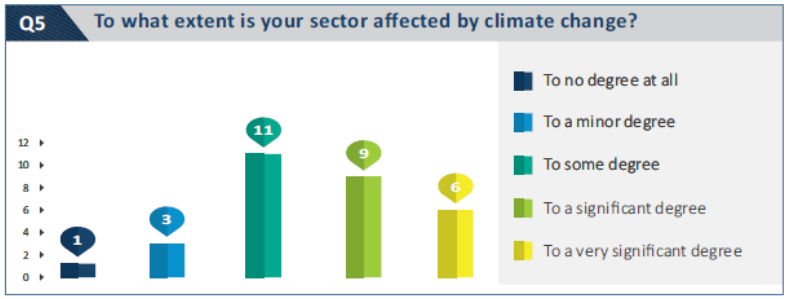
Top 20 Emerging Technologies Through IERE Member Survey Results

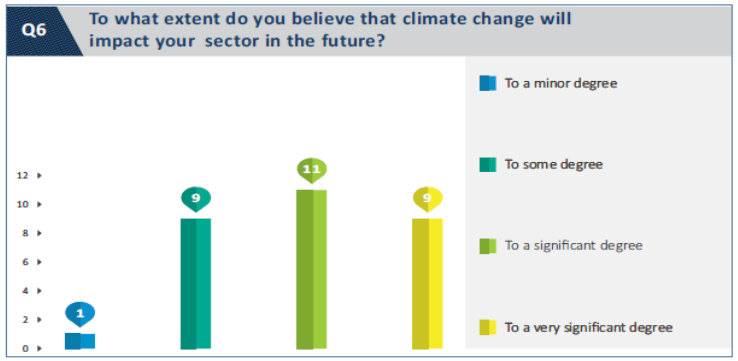


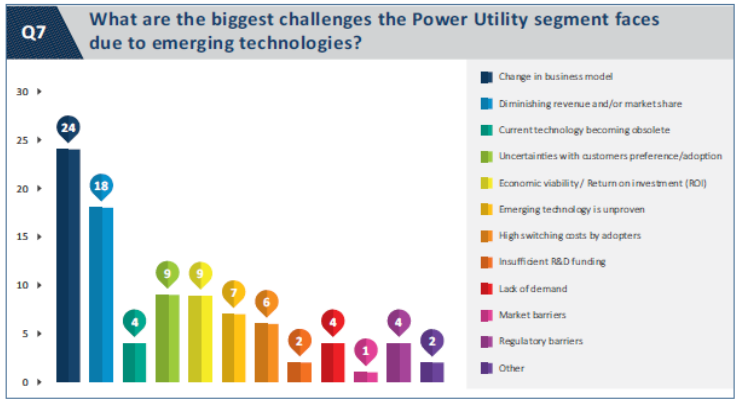












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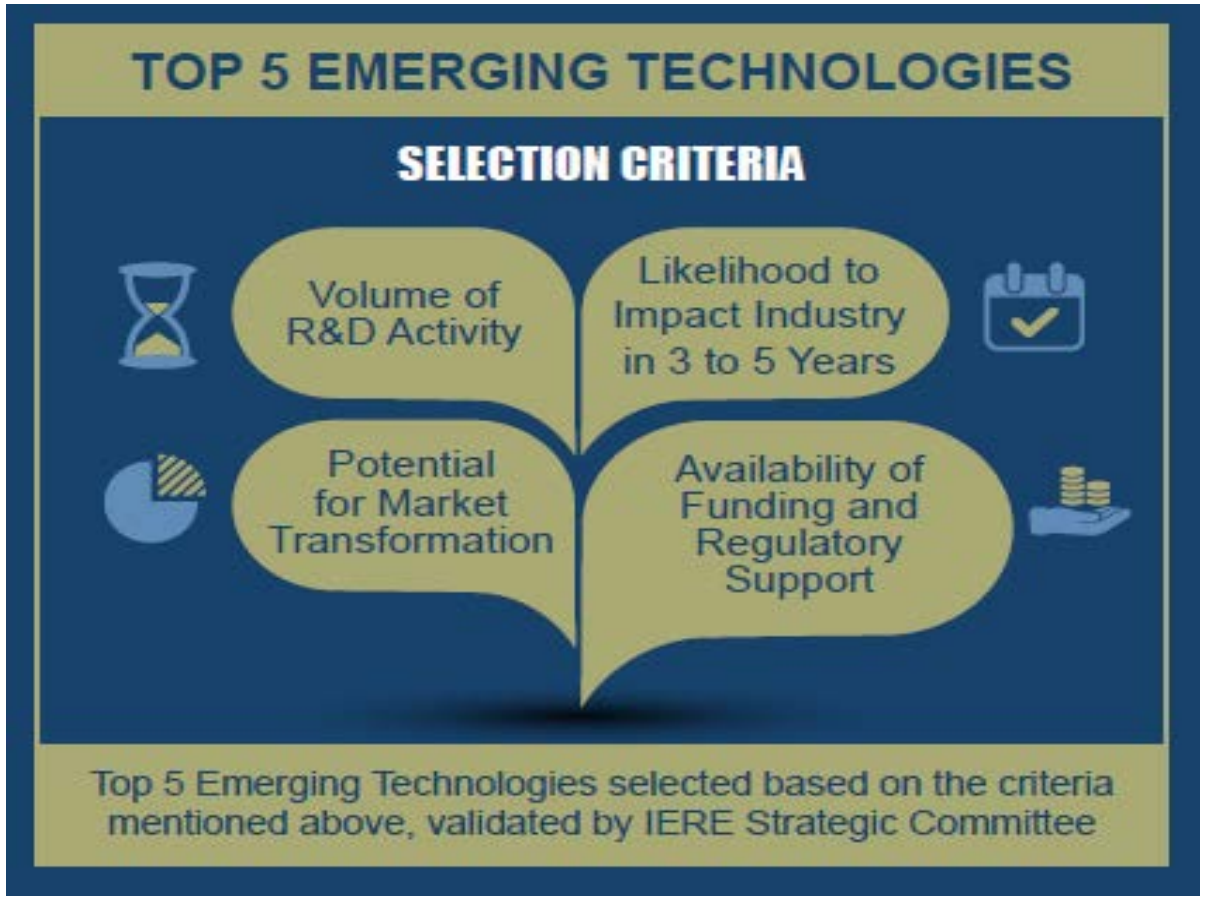
Top 5 Emerging Technologies



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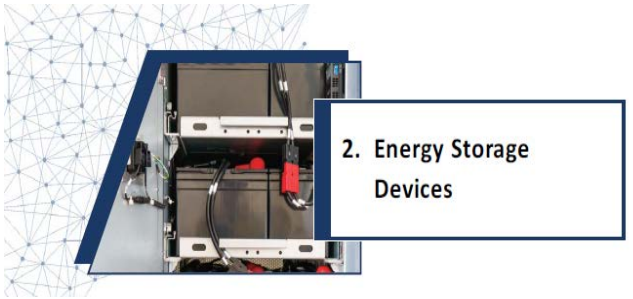
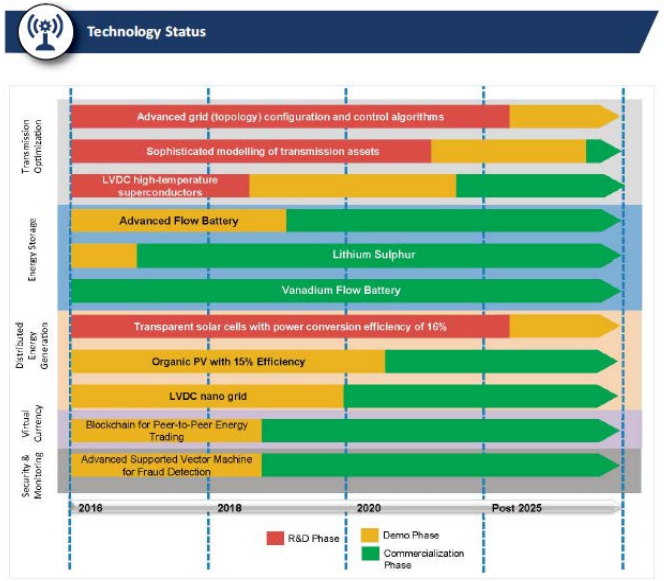
Top 5 Emerging Technologies

1. Prosumer Technologies

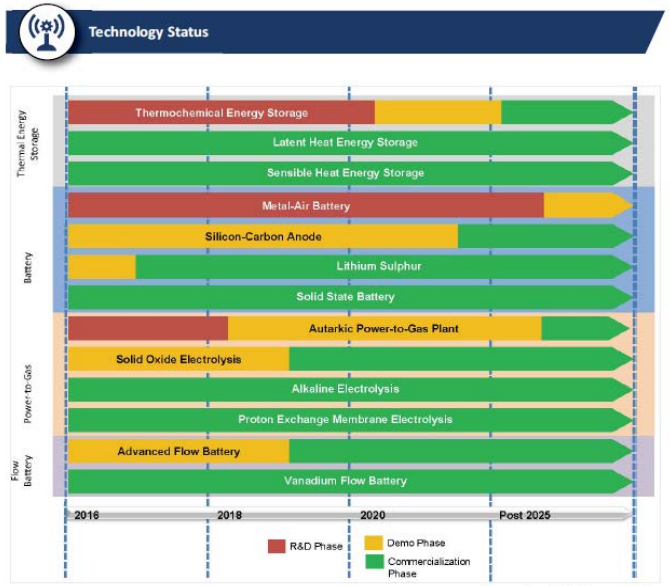


2. Energy Storage Devices

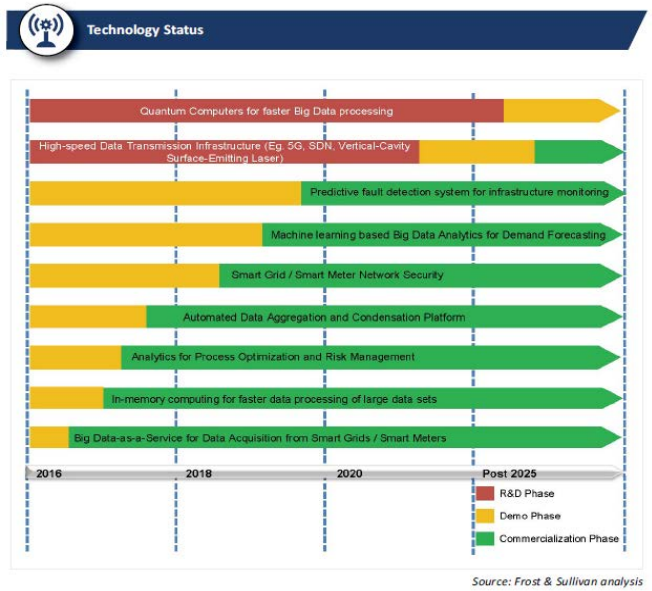
3. Big Data Applications



Source: Frost & Sullivan analysis

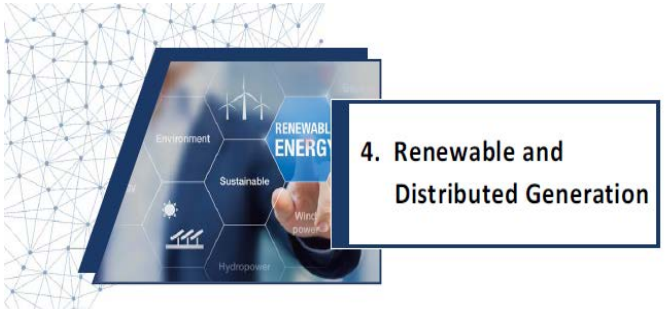


Source: Frost & Sullivan analysis

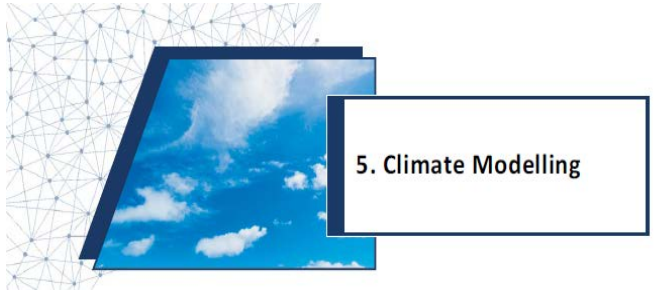


Source: Frost & Sullivan analysis

Top 5 Emerging Technologies (Cont'd)

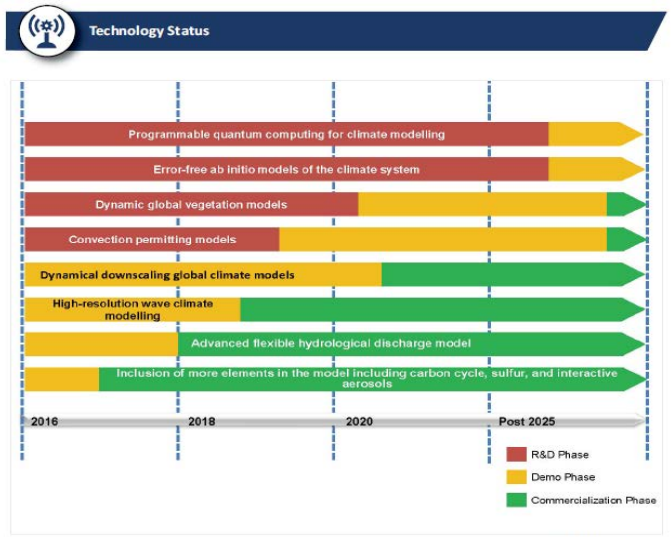


4. Renewable and Distributed Generation



5. Climate Modelling

Source: Frost & Sullivan analysis



Source: Frost & Sullivan analysis

IERE Technology Foresight 2020

Top 20 Emerging Technologies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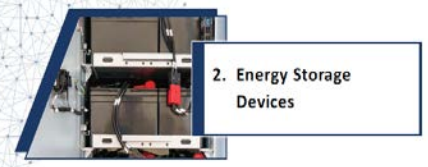
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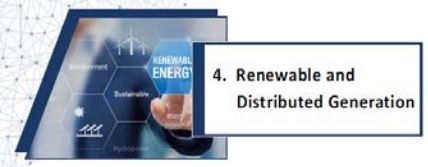
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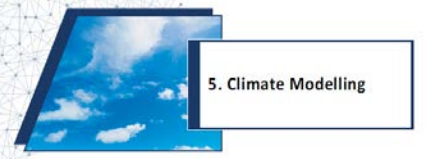
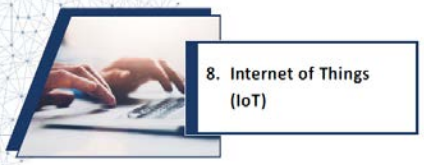
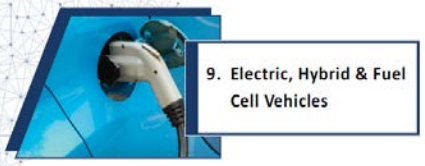

5. Climate Modelling


6. Smart Grid


7. Wireless Sensors

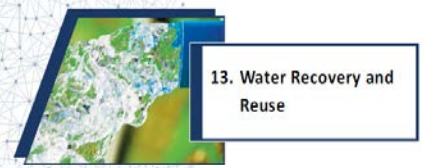

8. Internet of Things (IoT)

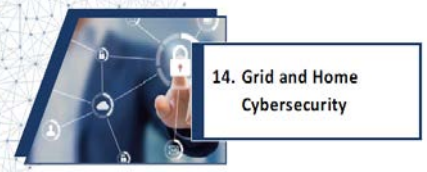

9. Electric, Hybrid & Fuel Cell Vehicles


10. Lithium-ion Battery

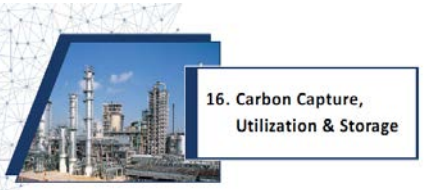

11. Smart X

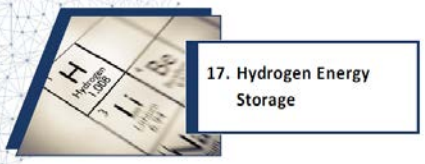

12. Water Resource Planning

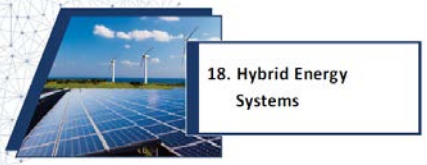

13. Water Recovery and Reuse

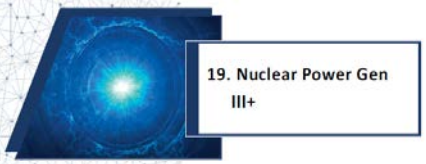

14. Grid and Home Cybersecurity

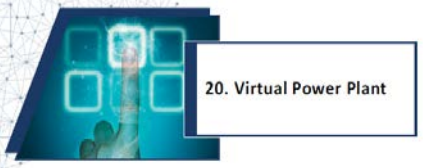

15. Offshore Wind


16. Carbon Capture, Utilization & Storage

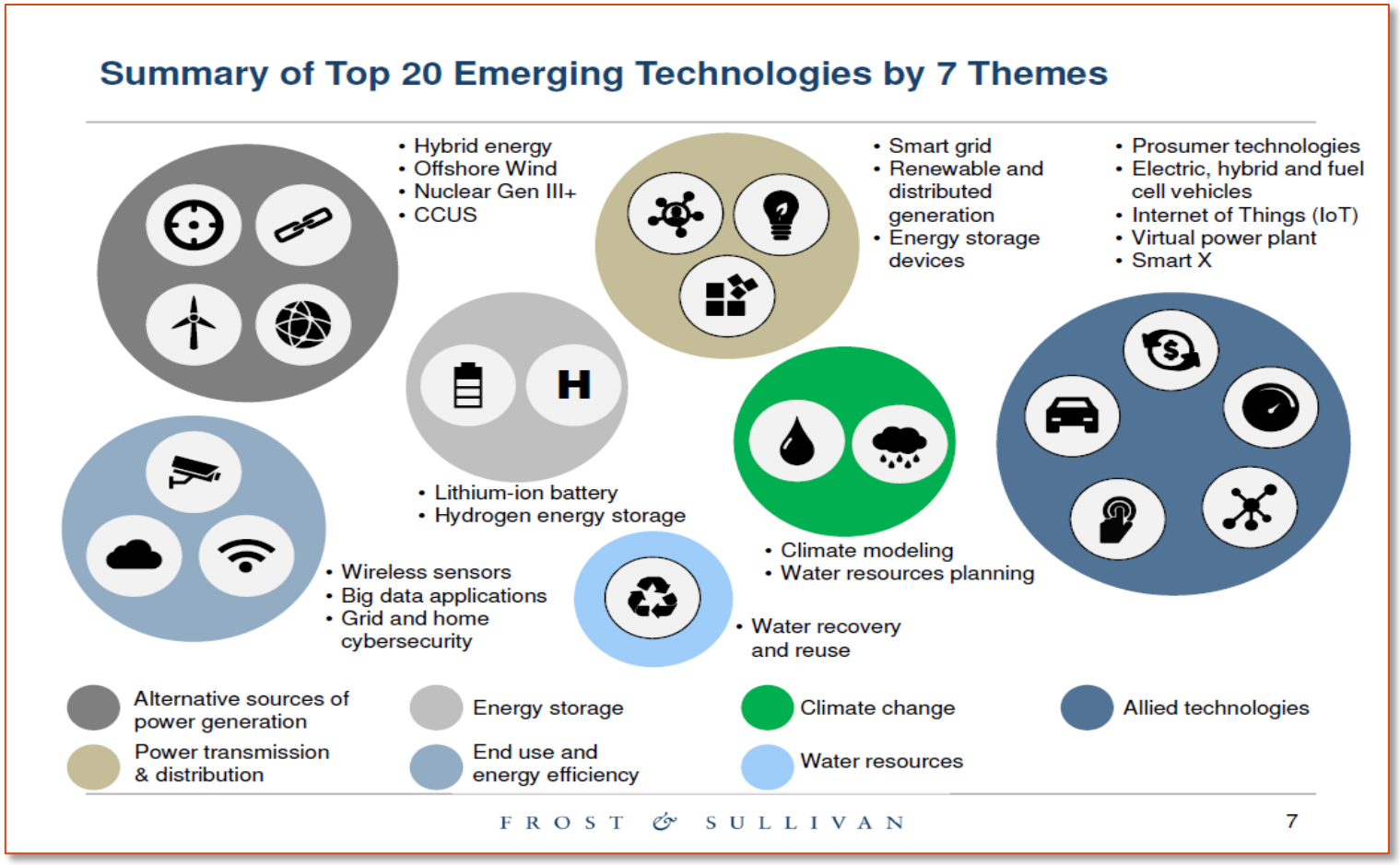

17. Hydrogen Energy Storage


18. Hybrid Energy Systems

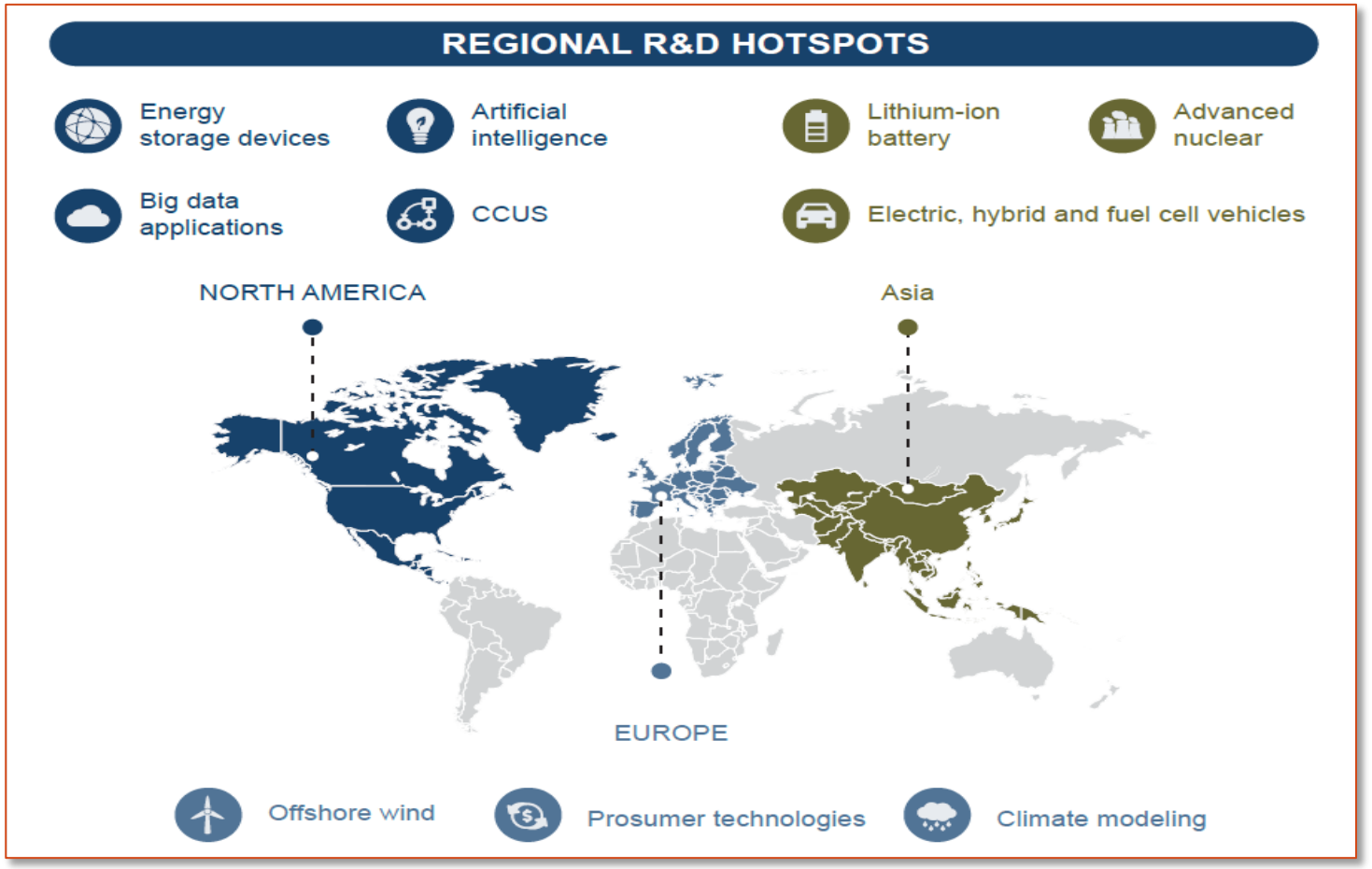

19. Nuclear Power Gen III+


20. Virtual Power Plant

Technologies by themes



Regional R&D Hotspots



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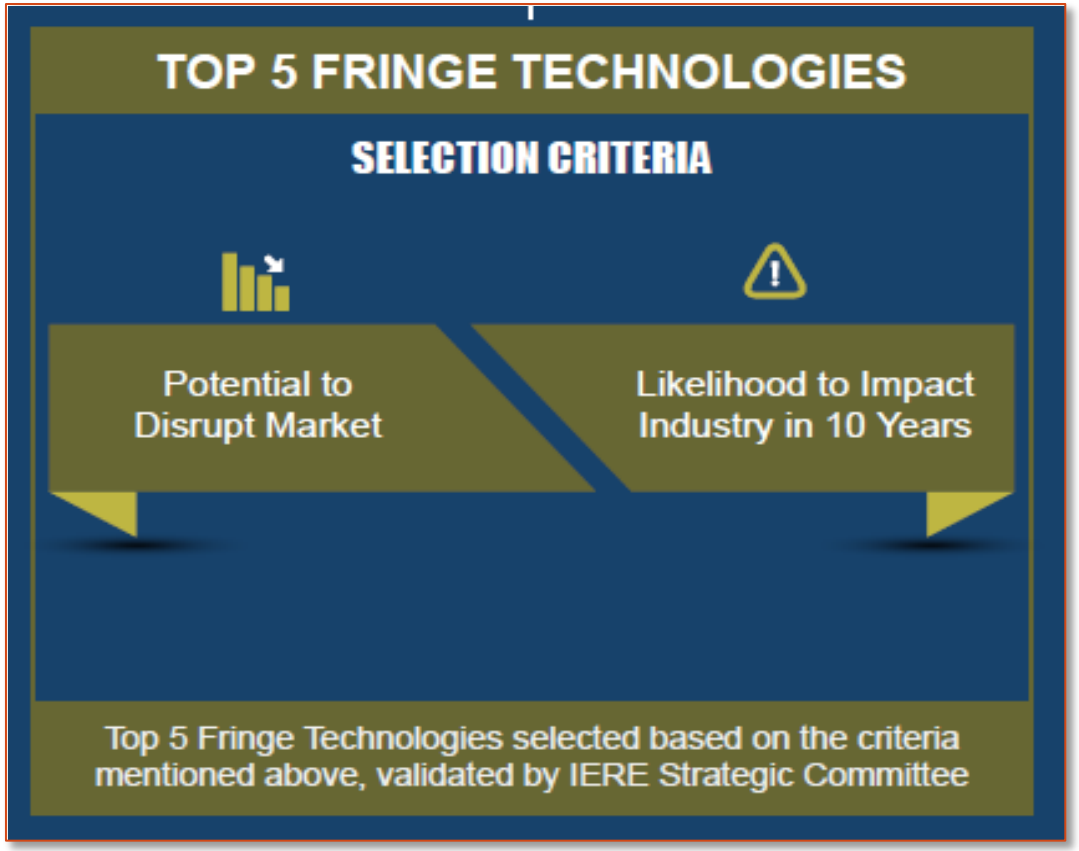
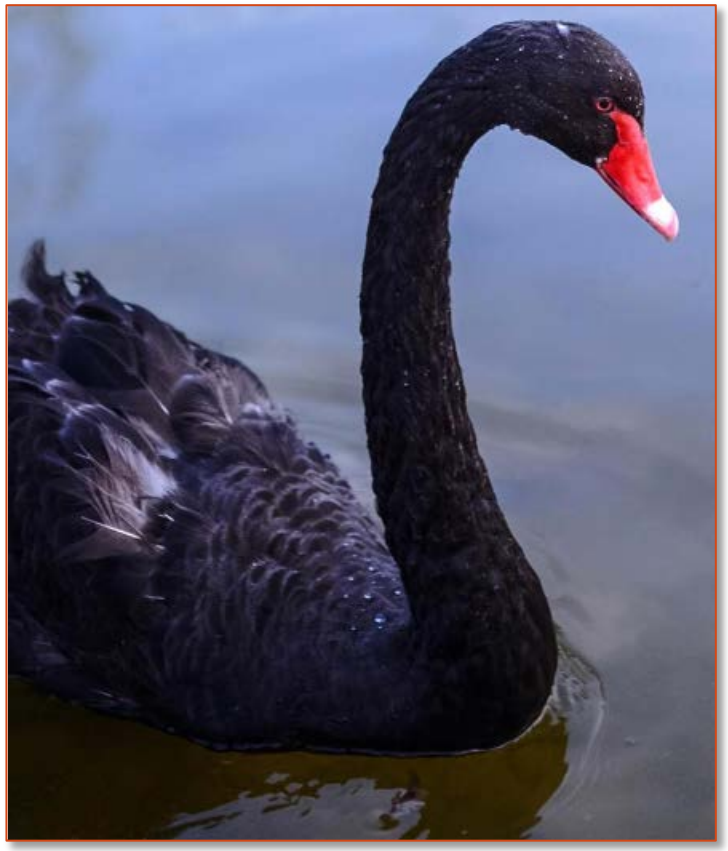
Top 5 Fringe Technologies

-remote possibilities but potentially disruptive (black swan)





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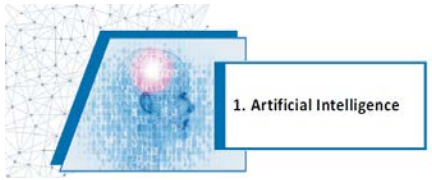
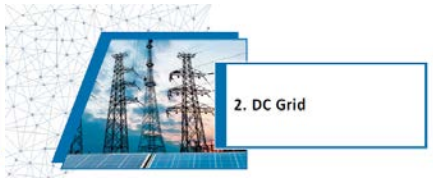
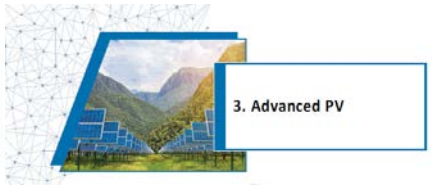
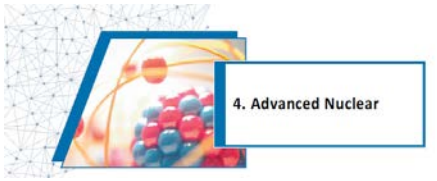
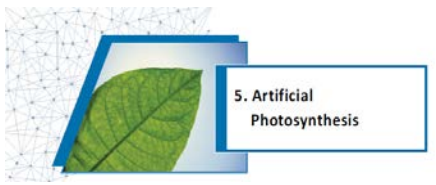
Top 5 Fringe Technologies

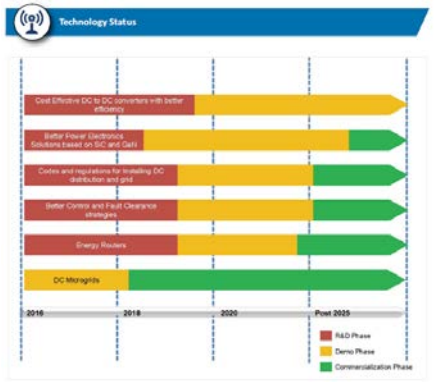


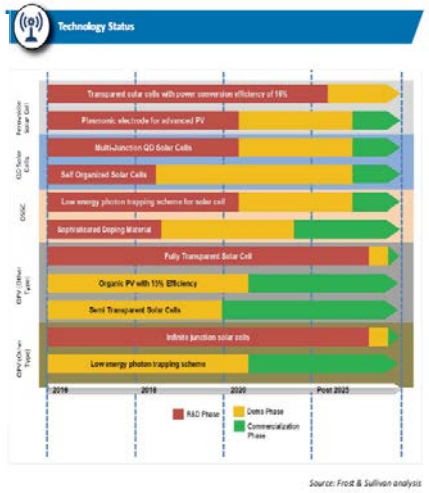


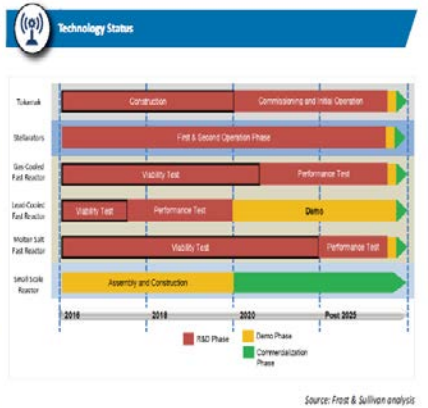


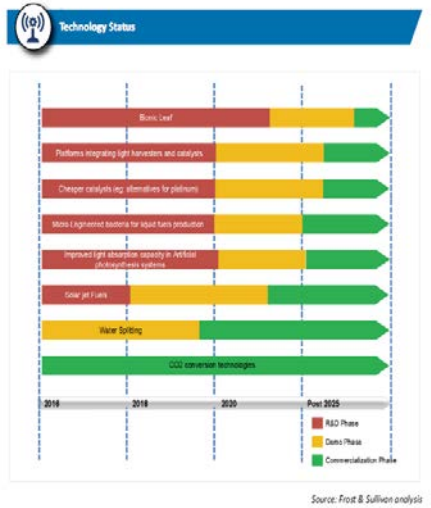












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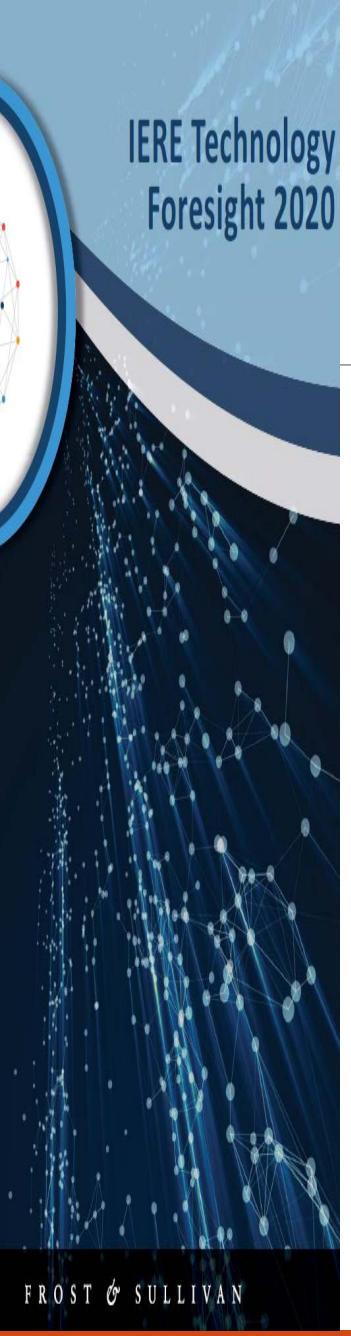


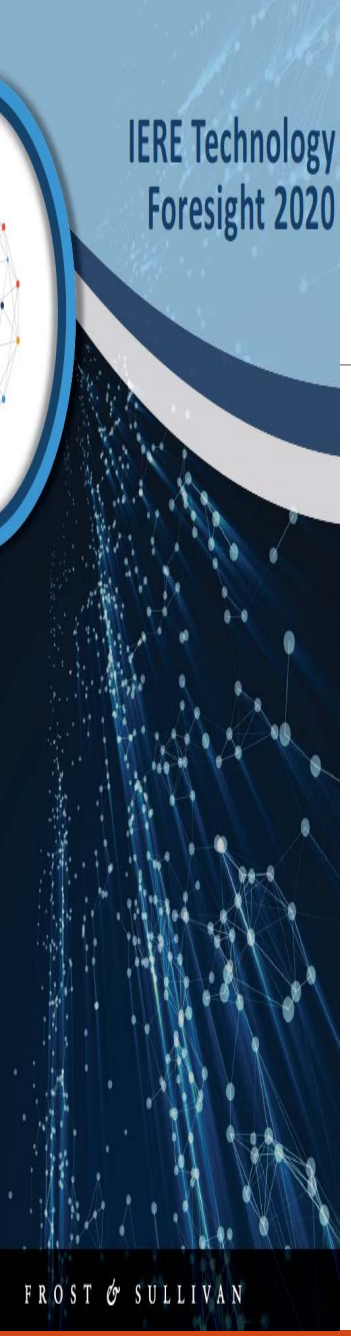
Next Step

IERE Central Office
Will distribute the final report in May 2017 to current & former members to seek their feedback

IERE Central Office
Will seek the Board's approval to release the report to the public under the IERE website after the official launch to the members. Exact date will be determined by the Board.

TF Committee
Will assess the result of TF2020 and recommend the potential next step

IERE Central Office
Will consider the idea of asking members to select two fringe technologies and nominate a young researcher from their own organization to form a research team to study the fringe technologies with other nominees. The findings may be part of the next TLM contents.



Outlook

- Electric industry is in a state of flux today and transitioning to a low-carbon future and even transformation are inevitable for all… R&D is an important means to reduce uncertainties, open up new ground and create new opportunities

- IERE constitutes a solid group of electric utilities and researchers who understand the technologies and their implications (both challenges and opportunities)

- The IERE Technology Foresight 2020 is an inaugural publication to facilitate more discussions on common interests, entice more joint research topics and/or projects to advance our knowledge and cooperation amongst the IERE members and beyond.

From the Chairman & Secretary General

IERE Chairman Message

The power system is changing at an exponential pace into a highly interconnected, complex, and interactive network of power systems, telecommunications, the Internet, and electronic commerce applications. Virtually every element of the power system will need to incorporate sensors, communications and computational ability.

No longer will society depend primarily on central station power and one-way flow on the grid, since the use of distributed generation, distributed energy storage and smart cities will proliferate. At the same time, the move towards competitive electricity markets requires a much more sophisticated infrastructure for supporting the myriad of informational, financial, and physical transactions between the several members of the electricity value chain that supplements or replaces the vertically integrated utility. Thus the rise of the "utility of the future" is upon us and thus requires a fundamental shift in our current thinking.

The IERE, a non-profit organization, serving the electricity industry across the world as a "global platform" of information exchange and collaboration in electricity technology research, development, demonstration, and deployment (RDD&D). In particular, IERE has three organizational missions:

- Evaluate innovative and emerging technologies and their implementation
- Help establish corporate strategy related to R&D under changing business climate
- Facilitate technology transfer from developed economies to developing economies

There are many factors driving the rapid changes in the worldwide electric industry today. Increased presence of non-conventional energy sources, advancement of utility grid operations technologies, and further penetration of enabling technologies that support demand-side resources are just few such examples. As an industry-leading organization with global and world-class expertise in supporting and promoting technology innovations in the global electric industry, IERE is in a strong position to provide thought leadership on technology solutions that could shape the future trajectory of the industry.

To this end, the IERE has undertaken a study in which a complete market survey and developed profiles of critical technologies that formed the foundation for our Technology Foresight 2016 report. The objectives for this report include:

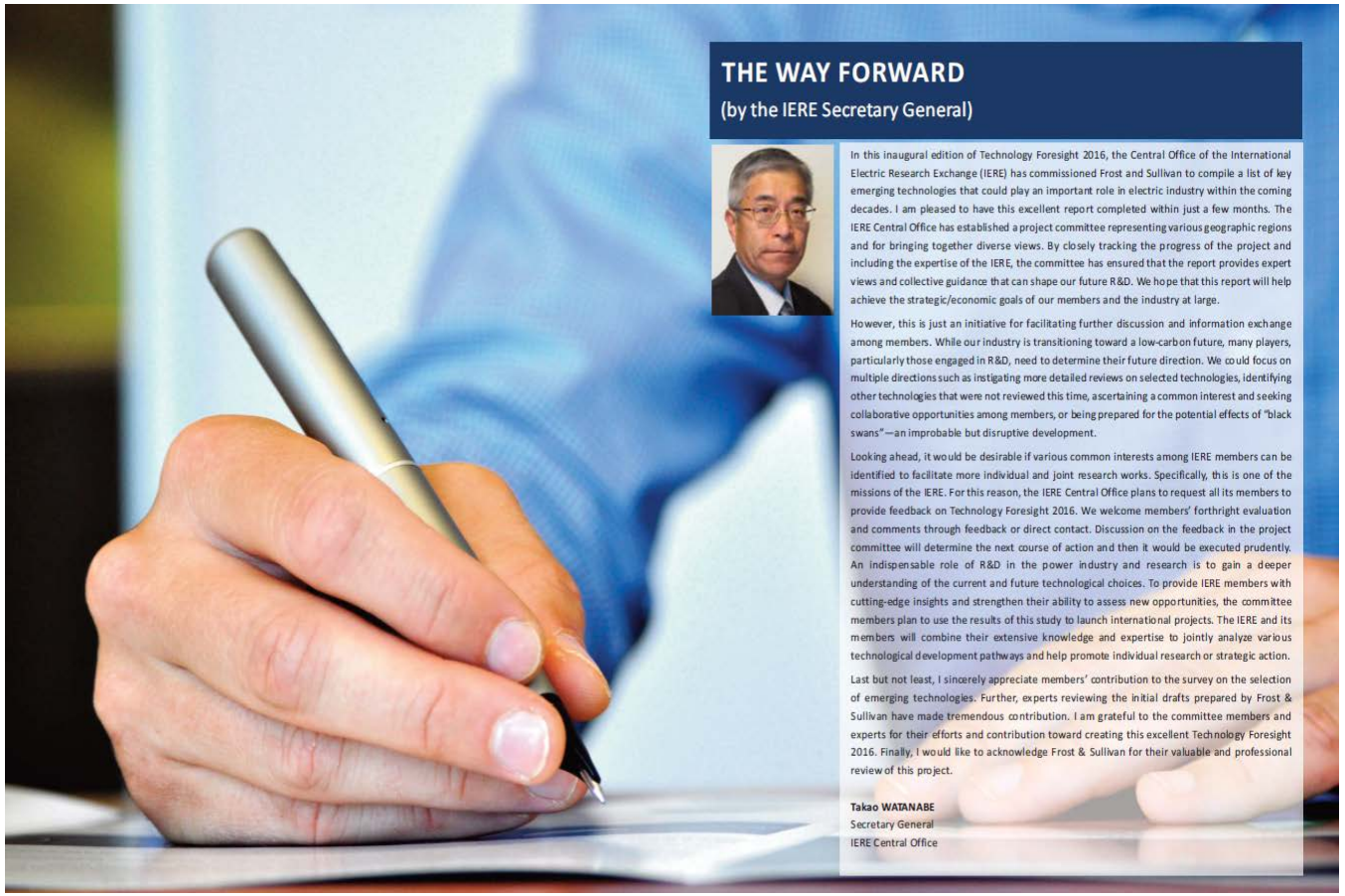
- Present the groups of technologies that IERE members identify as critical for the coming decades and addressing climate change
- Provide background information on the selected technologies (costs, development status, etc.)
- Provide information on IERE members' experts and projects related to these technologies

Given the global nature of IERE's vision and mission, IERE desires this report to not only be technology-agnostic, but also to address key technological changes on a global basis. This required the underlying analysis for the IERE Technology Foresight 2016 report to consider and reflect different concerns and aspirations that may vary widely from one region to another.

The key objective of the IERE Technology Foresight 2016 report is to provide up-to-date information with sufficient depth of technical background as well as strategic implications to its stakeholders. In particular, IERE would like this report to serve as an informative source of insight for those who may play a key role in promoting, collaborative in R&D activities.

In conclusion, on behalf of the Board members of the IERE, I wish to extend my gratitude and sincere thanks to the IERE Secretariat, the members of the Strategy Sub-Committee, for their endless hours of discussion, debate and input in meeting the challenge of producing an extremely informative and important study. I believe this has set precedent for the IERE to undertake further technology studies in the not too distant future, which I believe will and can only be of benefit our IERE members.

G R Tosen
Chairman IERE



THE WAY FORWARD
(by the IERE Secretary General)

In this inaugural edition of Technology Foresight 2016, the Central Office of the International Electric Research Exchange (IERE) has commissioned Frost and Sullivan to compile a list of key emerging technologies that could play an important role in electric industry within the coming decades. I am pleased to have this excellent report completed within just a few months. The IERE Central Office has established a project committee representing various geographic regions and for bringing together diverse views. By closely tracking the progress of the project and including the expertise of the IERE, the committee has ensured that the report provides expert views and collective guidance that can shape our future R&D. We hope that this report will help achieve the strategic/economic goals of our members and the industry at large.

However, this is just an initiative for facilitating further discussion and information exchange among members. While our industry is transitioning toward a low-carbon future, many players, particularly those engaged in R&D, need to determine their future direction. We could focus on multiple directions such as instigating more detailed reviews on selected technologies, identifying other technologies that were not reviewed this time, ascertaining a common interest and seeking collaborative opportunities among members, or being prepared for the potential effects of "black swans"—an improbable but disruptive development.

Looking ahead, it would be desirable if various common interests among IERE members can be identified to facilitate more individual and joint research works. Specifically, this is one of the missions of the IERE. For this reason, the IERE Central Office plans to request all its members to provide feedback on Technology Foresight 2016. We welcome members' forthright evaluation and comments through feedback or direct contact. Discussion on the feedback in the project committee will determine the next course of action and then it would be executed prudently. An indispensable role of R&D in the power industry and research is to gain a deeper understanding of the current and future technological choices. To provide IERE members with cutting-edge insights and strengthen their ability to assess new opportunities, the committee members plan to use the results of this study to launch international projects. The IERE and its members will combine their extensive knowledge and expertise to jointly analyze various technological development pathways and help promote individual research or strategic action.

Last but not least, I sincerely appreciate members' contribution to the survey on the selection of emerging technologies. Further, experts reviewing the initial drafts prepared by Frost & Sullivan have made tremendous contribution. I am grateful to the committee members and experts for their efforts and contribution toward creating this excellent Technology Foresight 2016. Finally, I would like to acknowledge Frost & Sullivan for their valuable and professional review of this project.

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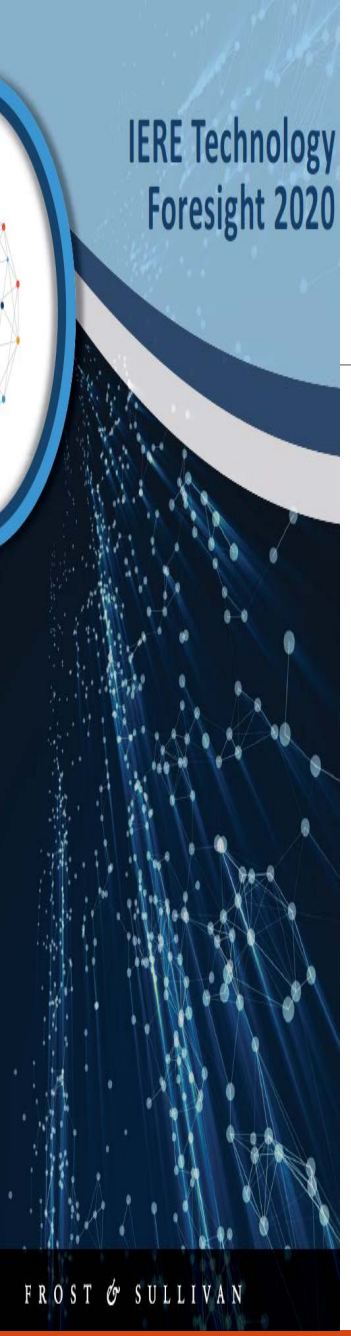

Question & Answer

Thank you