



**THE HONG KONG  
INSTITUTION OF ENGINEERS  
ELECTRICAL DIVISION**

*The 27th Annual Symposium*

Thursday

22nd October 2009

***ENGINEERING THE CHANGES***

at

Ballroom  
Sheraton Hotel  
Nathan Road  
Kowloon  
Hong Kong

## **SYMPOSIUM PROGRAMME**

**08.30 Registration and Coffee**

**09.00 Welcome Address**

- Ir Simon F.W. Chung  
Chairman, Electrical Division, The HKIE

**09.05 Opening Address**

- Ir Dr F.C. Chan  
Vice President, The HKIE

**09.10 Keynote Speech**

- Professor Andrew McCusker  
Operations Director  
MTR Corporation Limited

### ***1. Carbon Reduction***

**09.40 A Technology Roadmap Towards a Low Carbon Electric System**

- **A Utility's Experience Sharing**
  - Ms Priscilla P.S. Lee, Energy Technologist
  - Ir Dr John W.M. Cheng, Program Development Manager
  - Mr C.C. Ngan, Innovation Architect  
CLP Research Institute Ltd.
  - Mr Andrew Kinross, Director/Energy  
Navigant Consulting, Inc.

**10.00 Green Technology Applications to Combat Climate Change -  
An Electrical Engineering Perspective**

- Ir Dr F.C. Chan  
General Manager  
CLP Engineering Ltd.

**10.20 Discussion**

**10.40 Coffee Break**

## ***2. Emerging Technologies***

### **11.10 State-of-the-art Batteries for Electric Vehicle and Industrial Applications**

- Mr Kevin K.M. Yiu  
Business Development Director  
EVB Technology (HK) Limited

### **11.30 Enhanced System Reliability – Perspective from Distribution Cable/Materials**

- Dr Peter K. Pang  
End-Use Marketing Manager  
Dow Wire & Cable  
Dow Chemical (China) Investment Co. Ltd.

### **11.50 Contemporary Design of Electrical and Vertical Transportation Systems for Super High-rise Buildings in Mainland China and Hong Kong**

- Ir H.K. Yung, Director  
Ir Tony C.F. Lau, Associate Director  
Ir Tony C.W. Leung, Associate  
J. Roger Preston Ltd., Hong Kong

### **12.10 Discussion**

### **12.30 Lunch**

## ***3. Asset Management***

### **14.15 Smart Use of System Control Statistical Data to Enhance Power System Operations**

- Mr Dennis K. Wong  
Vice President, Business Development  
ASAT Solutions Inc., Canada

**14.35 Fibre Bragg Grating Sensor Networks for Condition-Monitoring of Railway System**

- Professor H.Y. Tam  
Director  
Photonics Research Centre  
The Hong Kong Polytechnic University

**14.55 Discussion**

**15.15 Coffee Break**

**4. *Migrating to New Era***

**15.45 Evolution in Electrical Engineering Curriculum**

- Ir W.K. Lee, Senior Teaching Consultant
- Ir Dr Wilton W.T. Fok, Senior Teaching Consultant
- Ir Professor K.T. Chau, EE Programme Director
- Ir Professor Felix F. Wu, Chair Professor  
Department of Electrical and Electronic Engineering  
The University of Hong Kong

**16.05 2009 Edition of Code of Practice for the Electricity (Wiring) Regulations**

- Ir Y.H. Leung, Senior E&M Engineer
- Ir Y.T. Wong, E&M Engineer  
Electrical and Mechanical Services Department  
The Government of the HKSAR

**16.25 Discussion**

**16.45 Summing Up**

- Ir S.K. Ho  
Symposium Chairman  
Electrical Division, The HKIE

**Closing Address**

- Mr Ricky W.K. Wong  
Chairman  
Hong Kong Broadband Network Limited

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<b>Ms Priscilla P.S. Lee</b>	<b>Professor H.Y. Tam</b>
<b>Mr John W.M. Cheng</b>	<b>Ir W.K. Lee</b>
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**Paper No. 1**

**A TECHNOLOGY ROADMAP TOWARDS A LOW CARBON  
ELECTRIC SYSTEM – A UTILITY’S EXPERIENCE SHARING**

**Speakers : Ms Priscilla P.S. Lee, Energy Technologist  
Ir Dr John W.M. Cheng, Program Development Manager  
Mr C.C. Ngan, Innovation Architect  
CLP Research Institute Ltd.  
Mr Andrew Kinross, Director/Energy  
Navigant Consulting, Inc.**

# A TECHNOLOGY ROADMAP TOWARDS A LOW CARBON ELECTRIC SYSTEM – A UTILITY’S EXPERIENCE SHARING

Ms Priscilla P.S. Lee, Energy Technologist  
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Mr Andrew Kinross, Director/Energy  
Navigant Consulting, Inc.

Paper  
No. 1

## ABSTRACT

The power industry is confronted with the urgency of climate change, environmental concerns and regulatory pressure to move towards a low carbon environment. In the face of these emerging issues, utilities are turning to clean energy and technological innovations to lower carbon emissions. This paper presents a power utility’s experience in developing a technology roadmap for the transition to a low carbon electric system. As the issue of climate change does not have a silver bullet solution, a portfolio approach was used to identify a range of key technologies to achieve low carbon energy. The spectrum of technologies includes renewable energy resources, carbon capture and storage, as well as green and innovative energy services.

## 1. INTRODUCTION

The environmental challenges faced by today’s power industry are quite daunting. The issue of climate change in particular requires that the industry respond quickly to avoid irreversible impact. There are few existing solutions but a range of new technological solutions are emerging in the horizon. In order to deploy the technologies effectively to address climate change, technology planning is critical. One tool for technology planning is a technology roadmap <sup>[1]</sup>. This paper offers a look at how one utility develops a technology roadmap to strategize its approach for addressing climate change.

## 2. WHAT IS A TECHNOLOGY ROADMAP?

A technology roadmap is a tool used to identify the critical technologies necessary for meeting specific objectives. Such a roadmap can have different applications under various settings. An industry may use a technology roadmap to identify and address technology challenges for the future development of the sector. A company may use a technology roadmap to establish the framework for developing a particular new product.

Some examples of technology roadmaps used in the energy sector include those developed by Electricite de France (EDF) and Continental Automated Buildings Association (CABA). EDF R&D through its Demand Response Technology Roadmap identified the controls, internet standards, and tariff structures that will help the development of demand response and smart homes <sup>[2]</sup>. The CABA technology roadmap describes the current and evolving intelligent building technologies, such as intelligent lighting, voice and data communications, and energy management systems. CABA also uses its technology roadmap to recommend actions for the building industry to promote the application of intelligent building technologies <sup>[3]</sup>.

Although there is no standard structure for the technology roadmap process, the development of a roadmap typically begins with a vision of a future scenario, challenge, or issue that can not



be addressed with existing technologies. Then the technologies that are essential to closing the gap between now and the future are identified and prioritised. In other words, a technology roadmap is a strategic approach towards a future objective.

### 3. EXPERIENCE OF DEVELOPING A UTILITY’S TECHNOLOGY ROADMAP

#### 3.1 OBJECTIVE

Power utilities worldwide are facing the issue of climate change. One approach to addressing this issue is by developing a technology roadmap that identifies the technologies needed for transforming a largely conventional fuel portfolio to one that uses low-carbon technologies.

As a major power utility operating throughout the Asia-Pacific region, CLP has set aggressive carbon emissions intensity reductions target through its Climate Vision 2050 initiative [4]. Through the initiative, the company committed to a 75% reduction in carbon intensity relative to year 2007 emissions. The company developed a technology roadmap that outlines the key technologies that will be important for transforming to a low-carbon portfolio. This paper shares the experience of developing such a roadmap.

#### 3.2. METHODOLOGY

The development process began with the identification of a broad range of technologies that can potentially impact the power industry. These identified technologies became the basis of the Technology Atlas; that is all those innovations which should be monitored for developments.

While a spectrum of potential challenges facing the power industry was considered, climate change was one of the significant issues that called for a targeted low-carbon technology roadmap. Selective innovations from the Technology Atlas that can

significantly mitigate the climate change challenge from a utility standpoint were integrated into the low-carbon technology roadmap.

As a first step to identifying and prioritizing the technologies and innovations that could potentially impact the power industry, we took the “universe” of technologies and put it through a screen to identify which ones would be best suited to meet the company’s needs. Key criteria that were considered included the following:

- Time to commercialization
- Potential for market transformation
- Potential for strategic value to the company

We scored 80 technologies in all, based on a scoring system that defined how each technology would be scored and ranked with the goal being to identify the key technologies that most likely contribute to solving the challenges set out by the company.

Thirty-six technologies were short-listed from an original list of 80. We developed profiles of each of these technologies. After gaining insights and a deeper understanding of the potential of the different technologies from this exercise, we then conducted another screen to find out the technologies that were really going to be the critical ones in the roadmap. Following that selection we developed reports one level of detail greater than the prior reports.

While the *mechanics* of the scoring and ranking ended up being a relatively straightforward exercise, the *insights* gained from the research on the potential impact of the different technologies was considerable. The scope of the researched topics is described in the subsequent section.

#### 3.3 SCOPE

Extensive research was conducted for each technology and innovation identified as having significant potential impact on the power industry. To help us better understand the development of the technologies, we analyzed factors ranging from market drivers to

development enablers and barriers. The scope of analysis for each technology and innovation are described below.

### 3.3.1 DRIVERS

These are the main drivers of developing and utilizing such a technology. For example, the drivers of *smart grids* would include preventing blackout, accommodating widespread deployment of intermittent distributed energy resources, growing needs to engage and accommodate customer-side interactions, requiring high efficiency, reliability and power quality for the digital age, climate-change and long-term business competitiveness considerations <sup>[5,6]</sup>.

### 3.3.2 POTENTIAL FOR MARKET TRANSFORMATION

Each technology included in the Atlas must have a certain level of potential to transform the industry. By means of transformation, we mean the new technology could do at least one or more of the following: 1) Add new value(s) to the customers/service provider; 2) Enable the conducting conventional business in a substantially more effective and efficient way; 3) Reduce the cost of the product/service significantly; and 4) Reduce the impact to the environment at an affordable cost. In fact, we realize different technologies could offer different types of transformation with different level of impact. Therefore, this section is to highlight the condition and reasons how a technology could transform the industry. We also assigned a High/Medium/Low to gauge the impact. For instance, *hydrogen-based applications* are still being developed currently. When hydrogen is produced by electrolysis, the low energy conversion efficiency is an obstacle. When hydrogen is used in stationary fuel cells for electricity generation, the high cost of fuel cells also remains a challenge. As such, the hydrogen technology is considered as Low at the moment <sup>[7]</sup>.

### 3.3.3 ECONOMICS

This is the economic overview/assessment of a

technology. We examine the cost and benefit of how the new technology can either replace or add to the existing market. It includes the cost trends and some projection if available. It is understood that all technologies we examine are not in a wide-spread deployment phase hence the detailed economic analysis are not necessary complete. However, we would try to use the most reliable and credible authorities such as International Energy Association (IEA), government reports and forecasts to estimate the likely trends and future paths. For example, *New Building Commissioning* is an approach which can make a new building to function efficiently and hence that could reduce a lot of wasteful consumption/emission. It was shown that in 2004, Lawrence Berkeley National Laboratory in the US released an analysis based on 20 years of data, that median commissioning costs for new buildings was US \$1 per square foot (0.6 percent of total construction costs), yielding a median payback period of 4.8 years if the technology is used <sup>[8]</sup>.

### 3.3.4 ADVANTAGES AND DISADVANTAGES

We use simple bullet form to highlight the pros and cons of implementing such a technology/innovation. For example, *synchronous condensers* can provide dynamic voltage support to uphold the system voltage and help improve reliability and vulnerability. However, its advantages and disadvantages could include:

- Able to cushion the effect of abrupt changes in grid system conditions
- Does not produce harmonic current that disturbs system performance
- Long lifespan, given proper maintenance
- Restrictions on deployment site locations
- Bulky, noisy and heavy hardware
- Sensitive to moisture, chemical contamination and dirt

### 3.3.5 ENABLERS AND BARRIERS

Wide-spread adaptation of a technology in any industry or the rejection of it does not merely

depend on cost alone. The enablers and barriers here provide some other technical and non-technical considerations which can make or break the taking-off of a technology. Quite often, the regulatory environment and market competition will play a key role in this. For example, for *geothermal generation*, these are the enablers and barriers:

- Policies promoting use of renewable energy
- Government grants of exploration licenses and development rights
- Advancement in rock drilling technology
- Permitting, legal, and environmental issues of enhanced geothermal systems (EGS) development
- High capital cost for EGS relative to natural gas plant
- Mismatch between geothermal sources and load centres

### 3.3.6 ALTERNATIVE/COMPETING TECHNOLOGIES

For considering a technology, we would also look at the alternatives and competing products. This is a different dimension from the cost as some technologies may offer multiple values to the customers/service providers and subsequently beating out the lower cost option.

For example, for *flue gas desulphurization*, the alternatives include burning low-sulfur coal and using multi-pollutant controls in power plants.

### 3.3.7 HOW IT WORKS

We consider it very important to establish an accurate and comprehensive understanding of the technology. Due to the rapidly changing technological development and proprietary issues, the description of each technology will give a snapshot of the key components or support needed to make the technology function and integrate with the rest. Here we provide an example description for *heat pump water heater (HPWH)*:

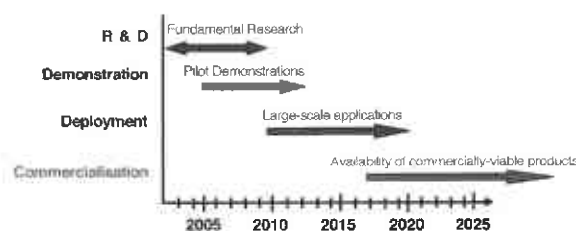
- HPWH transfer heat from the surroundings into the water tank. HPWH use electrically driven compressors to drive a vapour

compression cycle using conventional refrigerant as the working fluid. Newer HPWH use CO<sub>2</sub> as the working fluid to achieve higher water temperatures. In indoor applications HPWH have a cooling effect that may be beneficial in warm climates.

### 3.3.8 TECHNOLOGY STATUS

We use a graphical depiction similar to Figure 1 to summarize the current stage of the technology. Typically, there are four stages: 1) R&D phase - meaning the technology is in early stage of development which focus on basic and application research; 2) Demonstration phase - the technology is deployed for first commercial-scale applications; 3) Deployment phase - the technology is being wide-spread deployed and/or in large-scale application; and 4) Commercialization phase - the technology is available on the market but may be still expensive in comparison to conventional or alternative technologies.

**Figure 1 Example Technology Status Timeline**



### 3.3.9 R&D OBJECTIVES

We propose or highlight some of the R&D needs and trends within the industry as well as in the academics. It also serves to illustrate where some of the weak links are in the new technology. For instance, the followings are the R&D objective for *smart appliances*:

- Incorporate price signal reception capabilities into the system design
- Develop inexpensive technological solutions for retrofitting existing homes
- Integrate with other aspects of home automation systems (e.g., communications, entertainment, and security)

### 3.3.10 KEY DEVELOPMENTS/ DEMONSTRATIONS

In this section, we collect and summarize the key demonstration projects and/or product developments for the specific technology. As these demos and projects/programs have a wide variety, it may be best to illustrate with an example like in the *solid-state lighting* technology:

- In August 2008, the Summer Olympics in Beijing adopted LED lighting technology with the budget of about RMB¥ 0.5 billion and the estimated electricity savings of some 750MWh per year. The “Bird’s Nest” featured LED-lit signage and energy efficient lighting from various vendors. The “Water Cube” featured approximately 440,000 AAA XLamp LEDs embedded in the facade and structure of the building. BBB provided CFL, LED and solar-powered LED streetlamps for use on Olympic Buildings and around venues <sup>[10]</sup>.

### 3.3.11 KEY DEVELOPERS/RESEARCH ORGANISATIONS

This section includes the information of prominent/major entities who are either the technology provider, utility off-taker and/or developer; the location and commission date, capacity and application type.

### 3.3.12 POTENTIAL STRATEGIC VALUE TO THE COMPANY

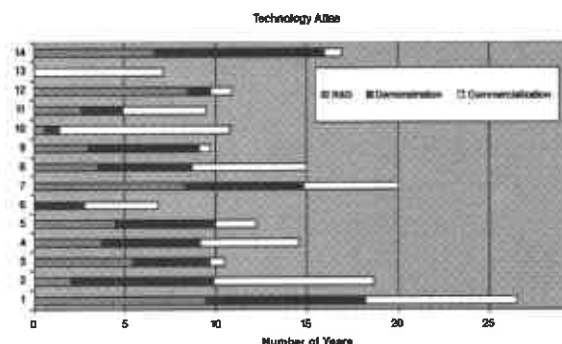
Finally, but not least, we conclude whether each of the technologies will be strategically important to the business, mainly from the perspectives of the maturity of the technology and its applicability.

## 3.4 TECHNOLOGY ATLAS

Given the above mentioned scope and criteria, we collect, review and analyze a broad range of technologies covering generation, delivery, emission control, operation and maintenance, environmental, storage, power electronics, energy efficiency, end-use, transportation and others. For each of the technology, we classify them into Research & Development, Demonstration or Commercialization stage and

then project the time duration for the development of each of these stages for the specified technology. At the end, a technology atlas similar to Figure 2 is obtained.

**Figure 2 Technology Atlas of Different Technologies**



From the Atlas, we can have a global view on which technology is closer in range to become commercially available and likely be competitive. In addition, we may also observe the likely relationships among the technologies (whether they are complementary or competitive to each other).

## 3.5 TECHNOLOGY ROADMAP

Based on the analysis conducted for the Technology Atlas, we examined the technologies and innovations that can significantly reduce carbon emissions and integrated these into the low-carbon technology roadmap. The low-carbon technology roadmap includes technology categories such as renewable energy and green energy and services.

The technology roadmap we have developed so far is high level and in broad terms. More efforts and works are necessary for detailed maps of those identified technology groups. Moreover, the technology roadmap itself and the preparation process have laid down a platform to facilitate on-going communication, engagement and consideration of technological matters at corporate levels.

In general, when developing a technology roadmap for individual organisations, each entity will need to consider its own relevant

factors for evaluating the applicability of different technologies. Each organisation will also need to determine the suitable approach for managing technologies at different development stages. As technology development is rapid with many uncertainties, the roadmap will have to be updated and modified periodically based on the latest regulatory, market and technology environment.

#### 4. CLOSING REMARKS

A technology roadmap is a useful tool for addressing large-scale challenges, such as climate change, that do not have a silver bullet solution. The approach presented in this paper is one example of the technology roadmap development process. Each organization will need to determine the technology types that are most applicable to it, such as the maturity of technology and the associated risks. Lastly, developing a technology roadmap is not a one-time process but rather a process that should be revisited periodically.

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#### REFERENCE

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