

# Preface

## Preamble

The CAETS CONVOCATION-2015, hosted by the Indian National Academy of Engineering (INAE), was held on 13 October–14 October 2015 at New Delhi, India. The CAETS Governing Council had chosen the theme on sustainable engineering pathways for energy, mobility and healthcare sectors for the conference attended by 250+ delegates comprising of the Fellowship of CAETS member academies, senior engineering experts, scientists, thought leaders, policy makers and industry executives from Belgium, Canada, China, France, Germany, Hungary, India, Japan, the Netherlands, South Africa, Spain, Sweden, Switzerland, UK, USA, Uruguay and other countries. This international event was formally inaugurated by Dr. Harsh Vardhan, Hon'ble Minister of Science and Technology, Government of India, and he assured that the recommendations of the CAETS Convocation will be acted upon by the government. Professor Asutosh Sharma, Secretary, Department of Science and Technology, Government of India, addressed the gathering and highlighted the importance of the selected themes to developing nations.

The two unique features of CAETS-2015 were the special gesture made by the INAE (a) to provide 50 % international travel support and complimentary accommodation to encourage young engineers below 45 years of age to deliver lectures in the technical sessions along with eminent senior engineers and (b) to organize poster sessions and awards to encourage very young engineers and research scholars from CAETS member academies to present their research work. These initiatives paid rich dividends by attracting the participation of 30+ young engineers in CAETS Convocation. Another major initiative is the formal launching of the electronic version of the CAETS report on “Transitioning to Lower Carbon Economy: Technological and Engineering Considerations for Building and Transportation Sectors” during the inaugural function of CAETS CONVOCATION-2015 by the chief guest. This is a joint initiative of 12 CAETS Member Academies from Australia, Canada, China, Germany, India, Japan, Korea, South Africa, Switzerland and UK. The experts from these academies met at Capetown (South Africa), Beijing

(China), Berlin (Germany) and London (UK) during 2013–2015 to identify the technological and engineering priorities and emerging options for transition to lower carbon economy in building and transportation sectors.

## **Recommendations**

### **Energy**

Global energy consumption will grow from 524 to 820 quadrillion BTU between 2010 and 2040, leading to GHG emission increase by more than 40 % from the present level under business as usual scenario. Since the dynamics of energy growth is driven by the population and wealth enhancements, it is important to keep track of these growth dynamics in different countries. Energy resources sustainability as well as their cost efficiencies would dictate as rapid shift as possible to lower carbon non-fossil energy systems. Since under this context, recent developments in three-stage thorium-based nuclear energy, large-capacity solar thermal power plants, fuel cell-based independent propulsion systems for strategic and civilian applications, wind-generated hydrogen as a renewable energy carrier and unconventional gas from coal seams, underground coal gasifications and biohydrogen from waste resources provide potentially lower carbon energy options. A joint voluntary initiative by CAETS member academies from Argentina, Australia, Canada, China, Germany, South Africa, Switzerland and UK on unconventional gas involving basic and social scientists, engineers and economists on unconventional gas provides a new model for CAETS member academies to emulate in the future.

Developing energy scenarios under various application modes is a powerful mechanism for devising future energy-efficient systems. A typical example is the highly interconnected electricity, transport and heating sectors. The coal-based energy continues to attract engineers to develop the cleaner process options and to minimize the GHG emissions keeping in mind the transitional priorities. The actions include upgradation of beneficiation, ultra-supercritical combustion and integrated gas combined cycle concept for gasification, cofiring of coal and biomass, and China's achievements in some of these areas are noteworthy. In energy materials, in which significant developments are taking place worldwide, we have to look beyond silicon for next-generation solar cells by adopting conjugate organics, inorganic quantum dots and mixed semiconductor oxides/peroxides. Similar challenges are foreseen in high-energy-density battery and membrane materials for fuel cells. Light-based technologies can play a major part in developing future energy-efficient systems. There is a need to integrate photonic and biophotonic technologies. In this international year of light technologies, such initiatives have to be taken to achieve multi-functionality, tunability, low power for fast operations, reconfigurability and cost-effectiveness so much necessary for energy, mobility and healthcare sectors.

The transition to lower carbon regime requires a careful assessment of current energy and emission loads at national level for setting energy/emission reduction targets and timelines. The selection of cost-effective technology and engineering options and their incentivization for creating new markets are the major challenges. The expert panel, which deliberated on these issues, stressed the need to develop high-strength lightweight materials including nanocomposites and nanostructured steels and bio-, electrochemical and catalytic options for hydrogen generation adaptable for building and transportation sectors. CAETS need to work closely with related international bodies such as World Economic Forum, International Panel on Climate Change and allied agencies.

## **Mobility**

The future engineering challenges lie in the development of semi- and fully automated transport vehicles, intelligent driver-vehicle interface and innovative multi-axle hydraulic trailers for heavy loads. The fast-changing digital technology has opened up new avenues for electrifications of rail, air and marine transport vehicles. The five digital forces, viz. cloud computing, mobile technologies, social networks, big data and robotics, will make high impact on these developments.

Exciting developments are taking place in bridge design and construction technologies with urban and rural transport restructuring, virtual mobility and carbon footprint minimization during their construction as defining factors. Novel retrofit technologies are needed for their restoration. A life cycle approach embracing bridge design, construction, maintenance, restoration and dismantling is a future priority area for civil engineers.

The recent developments in rapid urban rail transportation systems in China, India and Japan have demonstrated the new engineering skills acquired in the planning, design and execution of underground tunnels and structures. From material engineering point of view, material recycle and functionalized material applications are high priority areas in evolving sustainable roadways.

The dilemmas in mass transportation in emerging economies are many. It is important to consider seamless connectivity, smart mobility, enforcement of advanced safety measures, equitable allocations of road space for multiple type of vehicles and time-variant traffic demands.

## **Health Care**

Multitude of engineering challenges await healthcare sector in terms of new diagnostic tools, next-generation medical devices and application of informatics and analytics. The recent advances in nano- and point-of-care diagnostic, scalable medical and remote neonatal monitoring systems have enhanced the chances of early and accessible diagnosis. Structural process concept has greatly helped in developing groundbreaking technologies for these systems in advanced nations

with the help of multi-disciplinary teams comprising engineers, product designers, business analysts and clinicians.

The concept of regenerative engineering which combines tissue engineering, material science, cell physics and developmental biology has enabled the technologies for next-generation medical devices. Groundbreaking bionic ear and eye technologies have enabled notable progress against hearing and visual impairments. The recent advances in sensors, telecommunication and mobility engineering will play a major role in evolving next-generation device technologies for both communicable and non-communicable diseases. Sensing and data analytic skills provide new transformational material opportunities in intensive health care. Advanced computer-aided tools based on big data analytics are needed for biologically meaningful insights into the enormous volume of microbiome data generated from the sequencing platforms.

A panel of experts examined the issue of convergence of engineering and healthcare sciences. They are certain that the convergence is occurring impressively due to the application of ICT and big analytics in healthcare systems. Several key issues including affordability of well-engineered systems in rural and urban environments and engineers role in new drug discovery came up for discussion.

The major takeaways from CAETS Convocation are many. Achieving long-term sustainability under business as usual mode is virtually impossible in energy, mobility and healthcare sectors. Major emphasis has to be placed on energy consideration, expanded use of non-fossil primary energy, decarbonization of existing energy sources and enhancing the energy efficiency of individual systems. Higher investment in R&D and demonstration is essential for technologies which are close to market maturity and those requiring scale-up. Commitment from policy makers, different stakeholders, academic community and market leaders is very essential for the commercial realization. Ethical practices in engineering are vital for achieving high level of successes in every application field particularly so in creating human artefacts that are non-existent in nature. Gender enhancement in engineering design endeavours is essential for developing rational systems. Younger engineers have to be given increased responsibilities in evolving innovative engineering systems. The demand for novel engineering solutions will increase exponentially while developing smart energy, mobility and healthcare systems. Research, prototyping and technology transfers in such systems have to be pathbreaking in nature. The CAETS Engineering Community is committed to create a conducive environment for open access information sharing in the above sectors between the member academies.

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