



## INAE Monthly E-News Letter Vol. VII, Issue 1, January 1, 2016

### (+) Academy Activities

Academy News

(+) Articles by INAE Fellows

(+) I like to Say

(+) Engineering and Technology Updates

(+) Engineering Innovation in India

### Message from the President

On the eve of the New Year, I am delighted to convey my sincere greetings to all our Fellows, Young Associates and their families and wish each one of you a very happy [Read more...](#)

**Dr BN Suresh**  
President, INAE

### From the Editor's desk

#### Some Random Questions

Are the minds of engineers different, or is it a matter of opportunity and resources that makes an engineer? Are we cultivating the right kind of engineering mindset? Do only academic grades reflect the intelligence? What [Read more...](#)

**Pumendu Ghosh**  
Chief Editor of Publications

### Editorial Board, INAE

**Dr Purnendu Ghosh**  
**Dr Baldev Raj**  
**Dr K V Raghavan**  
**Dr Sanak Mishra**  
**Prof. Indranil Manna**  
**Prof BS Murty**  
**Prof Sanghamitra Bandyopadhyay**  
**Prof Pradip Dutta**  
**Prof Manoj K Tiwari**  
**Prof Sanjay Mittal**  
**Prof Prasun K Roy**  
**Brig Rajan Minocha**

### Message from the President

On the eve of the New Year, I am delighted to convey my sincere greetings to all our Fellows, Young Associates and their families and wish each one of you a very happy, healthy, successful and very productive New Year 2016. With your active participation, we are able to accomplish many milestones in the last one year and I must express my sincere thanks to all of you for your full hearted support and cooperation. I look forward for your greater association in our collective endeavour this year, so as to achieve greater excellence and make a visible impact in both national and international fora. Among various other activities of INAE, this year we hosted for the first time, the International Council of Academies of Engineering and Technological Sciences (CAETS) 2015 Annual Meeting and Symposium on "Pathways to Sustainability: Energy, Mobility and Healthcare Engineering" at New Delhi during October 2015, which was inaugurated by Dr Harsh Vardhan, Hon'ble Minister for Science & Technology and Earth Sciences. Another important event was the Engineers Conclave 2015 held at BARC, Mumbai, with the themes of "Green Energy" and "Clean India Technologies"; which was inaugurated by Shri Manohar Parrikar, Hon'ble Minister for Defence. It is heartening to note that in both these events, we had a large participation of our Fellows.

We have taken several steps to reach out to policy makers, stakeholders and other concerned Government Agencies. The vital and actionable recommendations, which have emerged out of the deliberations of the major events of the Academy have also been passed on to the right agencies for the appropriate action from their end. We have also initiated a few important studies on some the crucial areas of National importance which have been identified in the Vision Document of INAE released last year. We are very keen that the Academy, in addition to these tasks, acts as an advisory body for all matters pertaining to engineering and technology and provide very useful inputs needed for the development of the Nation.

The successful conduct of all these events have been made possible only due to the active participation and keen interest shown by the Fellows. The knowledge, wisdom and eminence of our Fellows have helped us in achieving several goals. On behalf of INAE, I convey my sincere thanks to all my Fellow colleagues in the Academy for their valuable contributions and look forward to have much greater and meaningful contributions in the forthcoming events and programmes being planned, this year too. I also welcome all the newly elected Fellows to INAE fraternity and solicit their active involvement in all our activities. We will be very happy to extend our assistance to all newly elected Fellows and to involve them in various activities and programmes of the Academy suiting to their area of specialization and expertise.

I also take this opportunity to seek your valuable suggestions for enhancing the effectiveness of the activities in the coming years. Let us together strive hard to achieve our set goals and also to take our activities to much greater heights.



**Dr BN Suresh**  
President, INAE

On the eve of the New Year, I am delighted to convey my sincere greetings to all our Fellows, Young Associates and their families and wish each one of you a very happy, healthy, successful and very productive New Year 2016. With your active participation, we are able to accomplish many milestones in the last one year and I must express my sincere thanks to all of you for your full hearted support and cooperation. I look forward for your greater association in our collective endeavour this year, so as to achieve greater excellence and make a visible impact in both national and international fora. Among various other activities of INAE, this year we hosted for the first time, the International Council of Academies of Engineering and Technological Sciences (CAETS) 2015 Annual Meeting and Symposium on "Pathways to Sustainability: Energy, Mobility and Healthcare Engineering" at New Delhi during October 2015, which was inaugurated by Dr Harsh Vardhan, Hon'ble Minister for Science & Technology and Earth Sciences. Another important event was the Engineers Conclave 2015 held at BARC, Mumbai, with the themes of "Green Energy" and "Clean India Technologies"; which was inaugurated by Shri Manohar Parrikar, Hon'ble Minister for Defence. It is heartening to note that in both these events, we had a large participation of our Fellows.

We have taken several steps to reach out to policy makers, stakeholders and other concerned Government Agencies. The vital and actionable recommendations, which have emerged out of the deliberations of the major events of the Academy have also been passed on to the right agencies for the appropriate action from their end. We have also initiated a few important studies on some the crucial areas of National importance which have been identified in the Vision Document of INAE released last year. We are very keen that the Academy, in addition to these tasks, acts as an advisory body for all matters pertaining to engineering and technology and provide very useful inputs needed for the development of the Nation.

The successful conduct of all these events have been made possible only due to the active participation and keen interest shown by the Fellows. The knowledge, wisdom and eminence of our Fellows have helped us in achieving several goals. On behalf of INAE, I convey my sincere thanks to all my Fellow colleagues in the Academy for their valuable contributions and look forward to have much greater and meaningful contributions in the forthcoming events and programmes being planned, this year too. I also welcome all the newly elected Fellows to INAE fraternity and solicit their active involvement in all our activities. We will be very happy to extend our assistance to all newly elected Fellows and to involve them in various activities and programmes of the Academy suiting to their area of specialization and expertise.

I also take this opportunity to seek your valuable suggestions for enhancing the effectiveness of the activities in the coming years. Let us together strive hard to achieve our set goals and also to take our activities to much greater heights.

It is with great pleasure that I once again wish all our Fellows, Young Associates and their families, a very Happy New Year filled with happiness, prosperity, peace, success and exceptional achievements in all their future endeavours.



Dr BN Suresh  
President, INAE

## **From the Editor's Desk**

### **Some Random Questions**

Are the minds of engineers different, or is it a matter of opportunity and resources that makes an engineer? Are we cultivating the right kind of engineering mindset? Do only academic grades reflect the intelligence? What about other associated facets of the mind? Since all students are not equal, why not cater to the needs of differing students and make their assessment accordingly? What is more important for an engineer – insight or precision? Can a person trained for expected problems deal with unexpected problems? What additional things are required to impart practice based experiential learning? Can routine engineering education inculcate and cultivate the desired engineering mindset? What a general engineering toolkit must contain? Is there a need for various engineering streams at the UG level? Shouldn't the practice of industry mentoring be taken more seriously? Why most engineers don't take as much pride in designing a thing and manufacturing it as they take pride in packaging it? We the people of India once believed that there was no country like ours, no king like ours, and no science like ours. Can we regain that spirit and that confidence? Can we, a country of 1.2 billion people, get back literally to zero?

I am sure you have many more questions. Please do write to us. We shall publish them in our column – I Like to Say.

It is said that the “most solid foundation for feeling better about the future is to improve it—tangibly, durably, reproducibly, and scalably.” If we wish to build a better future for ourselves we need to transform many yet proven theories into practice. We need to sharpen our ‘applied hope’. We can do it as we have appropriate head and heart to do it.

The ‘Year of Light’ is just over. In the New Year I wish you a most luminous 2016.



**Purnendu Ghosh**  
**Chief Editor of Publications**

## ACADEMY ACTIVITIES

## Message from the President

## From the Editor's Desk

## INAE Annual Convention

The Annual Convention of the Indian National Academy of Engineering was held on Dec 10-11, 2015, at Defence Institute of Advanced Technology (DIAT), Pune. The Inaugural Address was delivered by the Chief Guest Mr. Sajjan Jindal, Chairman, JSW Steel. Dr Surendra Pal, Vice-Chancellor, DIAT, Pune delivered the Welcome Remarks. Dr BN Suresh, President, INAE also delivered his Address during the Inaugural Session. The e-version of book titled "**Mind of an Engineer**" being published by M/s Springer which contains articles written by INAE Fellows on their personal experiences and career paths leading to their success as eminent engineers of the country; was released by the Chief Guest, Mr Sajjan Jindal. The website of the INAE Research Journal being brought out shortly titled "INAE Letters" developed by M/s Springer was also launched during the Inaugural Session of the Annual Convention. The Inaugural session also featured Award Lectures by Dr LK Singhal and Prof Sankar K Pal, Professor Jai Krishna Memorial and Professor SN Mitra Memorial Awardees 2015 respectively. Brig Rajan Minocha, Executive Director, INAE proposed the Vote of Thanks.

The major scientific and engineering highlights of the Convention were the presentations by newly elected Fellows and Young Engineer Awardees. The presentations were held in two Parallel Sessions on Dec 10-11, 2015. The list of the technical presentations by Fellows and Young Engineers are given below.

*Presentations by Newly Elected Fellows on Dec 10-11, 2015*

- |                                  |   |   |
|----------------------------------|---|---|
| Prof. Avinash K Agarwal          | - | Use of Lasers and Optical Diagnostics for Next Generation IC Engine Development |
| Mr. Rajeev M Pandia              | - | Engineering and Economics : Creation of Synergy                                 |
| Dr. SK Biswal                    | - | Technological Challenges on Low Grade Iron Ore Beneficiation                    |
| Dr BK Panigrahi                  | - | Advanced Signal Processing and AI techniques for Power Quality Assessment       |
| Dr. Kalyanasundaram Subramanian  | - | A Virtual Liver to Predict Liver Toxicity                                       |
| Dr. DR Prasada Raju              | - | Technological Solutions for Addressing Water Challenges in Rural Areas          |
| Dr. Lalit Kumar                  | - | Modern Microwave Tubes & Power Modules-Indigenous Technology Development        |
| Prof. Krishna Moorthy Sivalingam | - | Hybrid Optical-Packet Switching Architectures for Data Center Networks          |
| Dr. Manish Gupta                 | - | My Journey in High Performance Computing  |
| Prof. Santanu Bandyopadhyay      | - | Evolution of Pinch Analysis   |

- |                            |   |   |
|----------------------------|---|---|
| Mr. VN Heggade             | - | Sustainability Options for Design & Construction Practices in India   |
| Dr. P Sivakumar            | - | Development of Main Battle Tank Arjun and its Technologies  |
| Dr. Rajendra N. Basu       | - | Key materials issues to develop planar solid oxide fuel cell technology                                       |
| Prof. HB Hablani           | - | Applied Research and Teaching Contributions in Space Flight Vehicles Guidance, Navigation and Control at IITs |
| Mr. Arun Ramchandani       | - | New Product Development for Indian Defence  |
| Dr. Shivkumar Kalyanaraman | - | The Energy-Transportation Nexus   |
| Dr. Pushpak Bhattacharyya  | - | The Importance of Language Technology in our Life   |
| Mr. Narasimhan Venkatesh   | - | Multiprotocol Wireless in the Internet of Things  |
| Prof. Amrutur Bharadwaj    | - | On-chip Clock Delay Measurement and Applications  |
| Mr. SK Chande              | - | Generic Lessons from the Accident at Fukushima Nuclear Power Plant  |
| Dr. Amit Konar             |   | Brain-Computer Interfacing For Perceptual And Rehabilitative Applications                                     |
| Prof SN Singh              | - | Adaptive Wavelet Neural Network Based Long-term Wind Power Forecasting  |
| Prof. Bikramjit Basu       | - | Additive Manufacturing of three Dimensional Porous Scaffolds for Biomedical Applications                      |
| Prof. Indradev Samajdar    | - | Excitements in Microstructural Engineering  |
| Dr. V Narayanan            | - | Cryogenic Propulsion Systems Development in ISRO  |
| Prof. Amit Agrawal         | - | Blood plasma separation in a Microdevice  |
| Prof. Naresh Tandon        | - | Vibration and Acoustic Emission Monitoring of Ball Bearings   |
| Prof. Anindya Deb          | - | CAE-Driven Vehicle Crashworthiness and Occupant Safety Design   |
| Dr. Rajiv Tayal            | - | Journey of a Different Kind   |
| Dr. R Kothari              | - | Dimensionality Reduction  |
| Prof. Debabrata Das        | - | Biohythane process for the maximization of the gaseous energy recovery  |
| Prof. SA Soman             | - | Synchrophasor Analytics for Smart Electrical Transmission Systems   |

Prof Mukesh Sharma - Developing National Air Quality Index

***Presentations by INAE Young Engineer Awardees on Dec 10-11, 2015***

- Dr. K V Mani Krishna - Phase Transformation and Deformation Studies in Zr Based Alloys : Basic knowledge to Product development
- Dr Gurunath Gurralla - Overview of Research Contributions in Power System Stability and Control
- Dr. Deepak Padmanabhan - Fast, Accurate and Flexible Similarity Search
- Dr. Arindrajit Chowdhury - Combustion characterization of propellants
- Dr. Arvind Pattamatta - Energy Transport in micro and nano scales for microelectronic cooling application
- Dr V. V. Raghavendra Sai - Optical Chemical and Biosensors for Clinical Diagnosis and Environmental Monitoring
- Mr Jasbir Singh - Low Cost High Performance GNSS receiver
- Dr. Abhishek Kumar - Understanding the Role of Earthquake Source, Propagation Path and Local Site Effect in Controlling the Induced Effects of Earthquakes

***Award Function on Dec 10, 2015***

The Grand Award Ceremony was held on the evening of December 10, 2015. Five theses at Doctoral level, Five Theses at Master's Level and 8 Projects at Bachelor's Level were conferred the Innovative Student Projects Award. Ten candidates were conferred the INAE Young Engineer Award 2015.



*Dr Jagadish Vengala being conferred the Innovative Student Projects Award 2015 at Doctoral level by Dr BN Suresh, President, INAE*



*Dr VV Raghavendra Sai being conferred the INAE Young Engineer Award 2015 by Dr BN Suresh President, INAE*

Prof Kripa Shanker, Emeritus Fellow, Indian Institute of Technology Kanpur and Prof Dipak Mazumdar, Ministry of Steel Chair Professor, Indian Institute of Technology Kanpur were conferred the INAE Outstanding Teachers Award.



*Prof Kripa Shanker receiving the Outstanding Teachers Award 2015 from Dr BN Suresh, President, INAE*



*Prof Dipak Mazumdar receiving the Outstanding Teachers Award 2015 from Dr BN Suresh, President, INAE*

Dr LK Singhal, Director, JSL Ltd, Hisar and Prof Sankar K Pal, DAE Raja Ramanna Fellow, Distinguished Scientist and Former Director, Indian Statistical Institute, Kolkata were conferred the Prof Jai Krishna Memorial Award and prof SN Mitra Memorial Award 2015 respectively.



*Dr LK Singhal receiving the Prof Jai Krishna Memorial Award 2015 from Dr BN Suresh, President, INAE*



*Prof Sankar K Pal receiving the Prof SN Mitra Memorial Award 2015 from Dr BN Suresh, President, INAE*

Prof BL Deekshatulu, Formerly Director, National Remote Sensing Agency, Hyderabad and Prof DV Singh, Former Director, IIT Roorkee and Former Vice-Chancellor, University of Roorkee were conferred the Life Time Contribution Award in Engineering 2015.



*Prof BL Deekshatulu receiving the Life Time Contribution Award in Engineering 2015 from Dr BN Suresh, President, INAE*



*Prof DV Singh receiving the Life Time Contribution Award in Engineering 2015 from Dr BN Suresh, President, INAE*

### **Annual General Meeting of Fellows on Dec 11, 2015**

The 27<sup>th</sup> Annual General Meeting of Fellows was held on Dec 11, 2015. During the Induction Ceremony, the following were formally admitted into the Academy by the President, INAE and signed the Admission Register.

Mr. VN Heggade, Prof. Mukesh Sharma, Prof. Krishna Moorthy Sivalingam, Dr. Manish Gupta, Dr. Shivkumar Kalyanaraman, Prof. Pushpak Bhattacharyya, Dr. Amit Konar, Dr. Ravi Kothari, Prof. Avinash K Agarwal, Dr. P Sivakumar, Mr. Arun Ramchandani, Prof. Amit Agrawal, Prof. Anindya Deb, Prof. Naresh Tandon, Prof. VK Jain, Mr. Rajeev M Pandia, Dr. CV Rode, Prof. SN Singh, Prof. SA Soman, Dr. BK Panigrahi, Dr. Lalit Kumar, Mr. Narasimhan Venkatesh, Prof. Amrutur Bharadwaj, Prof. HB Hablani, Dr. V Narayanan, Dr. SK Biswal, Dr. Rajendra N. Basu, Prof. Bikramjit Basu, Prof. Indradev Samajdar, Prof. Santanu Bandyopadhyay, Mr. SK Chande, Prof. Debabrata Das, Dr. Kalyanasundaram Subramanian, Dr. DR Prasada Raju, Dr. Rajiv Tayal and Dr. S. Venkata Mohan.

During the Brainstorming session, Dr BN Suresh, President, INAE requested the Fellows to give their suggestions. A number of valuable suggestions were received on ways to enhance the visibility of the Academy in the industry and policy domains.

### ***Sidelines Meeting held on Dec 10, 2015***

A meeting of selected INAE Fellows chaired by Dr Anil Kakodkar, was held on Dec 10, 2015 on sidelines of the INAE Annual Convention to discuss and suggest recommendations on the ways to enhance the Academy and Industry Interactions and also to increase the outreach of INAE with policy makers and stakeholders. During the deliberations, a number of valuable suggestions have been received which will be progressed actively.

### ***Plenary Session on Dec 11, 2015***

A Plenary Session was held on Dec 11, 2015 during which the Plenary Lecture on “India’s Nuclear Strategy: Meeting Challenges from the Neighbourhood” was delivered by Dr Manpreet Sethi, Senior Fellow, Centre for Air Power Studies, New Delhi. The Award lectures by Prof Dipak Mazumdar and Prof Kripa Shanker, the Outstanding Teacher Awardees 2015 were also held during the Plenary session.

### **The Mind of an Engineer**

The book – The Mind of an Engineer – is an initiative of the INAE. It is a reflection of the experiences of some of the Fellows of the INAE in the field of science, technology and engineering. The book is about the reminiscences, eureka moments, inspirations, challenges and opportunities in the journey the professionals took toward self-realization and the goals they achieved. The book contains 58 articles on diverse topics that truly reflect the way the meaningful mind of an engineer works. The book is published by Springer. The e-version of the book was launched at The Annual Convention of Academy at Pune on 10<sup>th</sup> December 2015. The hard copy of the book will soon be dispatched to the Fellows of the INAE.

### **Creation of data for INAE Expert Pool**

A data bank of the expertise of the INAE Fellows is being created so as make the same available and facilitate the selection of experts in various projects/programmes which are undertaken from time to time. The aim of this expert pool is to provide an easy to access and retrieve search engine, to connect the experts to the individuals or agencies looking for their services. The benefits of creating the database include selection of professionals for Peer Reviewing of publications, examination of technical reports and project proposals, evaluation or assessment of thesis and constitution of expert committees for framing policies. All INAE Fellows have been requested to submit their profile details online at the link <http://inae.in/expert-search/index.php/inae-members-form>

### **International Conferences/Seminars being organized by IITs/other Institutions**

To view a list of International Conferences/Seminars being held in the month of Jan 2016 [click here](#).



## Honours and Awards

1	Dr G. Satheesh Reddy, FNAE, Scientific Adviser to Raksha Mantri has been conferred with the prestigious National Systems Gold Medal by the Systems Society of India and the first Institution of Engineers (India) IEI- Institute of Electrical and Electronic Engineers (IEEE –India) Award for Engineering Excellence for the year 2015.
---	--

## News of Fellows

1	Dr Baldev Raj, FNAE, Director, National Institute of Advanced Studies, Bangalore and Immediate Past- President, INAE has been appointed as Chairman, Board of Governors, National Design and Research Forum, The Institution of Engineers (India) for the year 2015-2016. He has also become Member, Karnataka State Council for Science and Technology; Member, Apex Council of Prime Minister's Fellowship Scheme for Doctoral Research and Industry Collaboration; Chairman, Task Force of CII for bridging Academia and Research, Industry collaboration in Higher Education and Co-Chairman, Science Policy Committee of DST.
1	Book published: ETHICS OF THE CHAIR by Dr Purnendu Ghosh, FNAE, Executive Director, Birla Institute of Scientific Research, Jaipur. The book is a reflection of the author's working at various institutions in the past four decades. Some of the truths that have guided him to maintain the ethics of his chair are: intentions and outcomes are not always the same though one wishes them to be so, life doesn't merely follow the rigid rules, half-truths are more dangerous than complete falsehoods, to become world class one must have the desire to become world class, intellect is essential part of any make-up, and respect the chair you occupy.

International Conference on Technological innovations in Mechanical Engineering (TIME-2016) on Jan 4-5, 2016 at Hyderabad

<http://www.conferencealerts.com/show-event?id=160194>

2016 First IEEE International Conference on Control, Measurement and Instrumentation (CMI 2016) on Jan 8-10, 2016 at Kolkata

<http://www.conferencealerts.com/show-event?id=148804>

Second International Conference on VLSI Systems, Architecture, Technology & Applications on Jan 10-12, 2016 at Bangalore

<http://www.conferencealerts.com/show-event?id=154322>

2nd International Conference on Computational Intelligence and Networks on Jan 11, 2016 at Bhubaneswar, Odisha

<http://www.conferencealerts.com/show-event?id=156038>

Biennial International Conference on Power and Energy Systems: Towards Sustainable Energy (PESTSE2016) on Jan 21-23, 2016 at Bangalore

<http://www.conferencealerts.com/show-event?id=149188>

International Conference on Innovative Research in Mechanical Engineering, Automotive and Aerospace Technology (MEAT-2016) on Jan 23, 2016 at New Delhi

<http://www.conferencealerts.com/show-event?id=163660>

International Conference on Innovative Research in Electrical, Electronics and Communication Technology (ECT – 2016) on Jan 24, 2016 at New Delhi

<http://www.conferencealerts.com/show-event?id=163662>

2nd International Conference On “Computer Science & Information Technology: Trends, Challenges and Issues 2016” (CSIT-TCI 2016) on Jan 29-30, 2016 at New Delhi

<http://www.conferencealerts.com/show-event?id=161044>

International Conference on Recent Advances in Computer Science, E-Learning, Information & Communication Technology (CSIT– 2016) on Jan 31, 2016 at New Delhi

<http://www.conferencealerts.com/show-event?id=163706>

## **Chennai Flood Disaster Catastrophe of December 2015- Are you listening?**

R. K. Bhandari Email:rajmee@yahoo.com

The worst is over and the city of Chennai in the State of Tamil Nadu in India is limping back to normalcy after the unprecedented flood catastrophe of December 2015. The whole country applauds the exceptional grit and grace with which the citizens of Chennai fought the fury of the floods as one single family of friendly strangers! When the Indian Armed Forces, the NDRF Battalions, the Paramilitary Forces, the State Police and the common men intermingled with the victims of the flood-ravaged city of Chennai on the mission to save lives, by heroic deeds they won the admiration and gratitude of the nation as a whole. India can be justly proud of the inspiring examples set out by the rescue teams and the citizens, in the defiance of death and destruction. The ensuing trail of success stories, which will be retold for generations to come, has reaffirmed peoples' faith in India's capacity to manage the post-disaster phase of the cataclysmic events.

Now imagine the dreadful scenario in the flood-ravaged Chennai without the timely and decisive interventions of the post-disaster response teams. The loss of lives, the number of those injured, the count of the homeless, trauma of the victims, damages to the infrastructure, the cost of recovery and construction and pressure of demand on local administration would have been several folds higher. On the other hand, imagine the scenario which could have developed to our advantage after implementation of preventive and mitigation measures in tune with the experiences gained and the lessons learned from as many as six major flood disaster events in the last 40 years. The loss of lives, damages to the infrastructure, the hefty relief package of Rs 1940 crores and the astronomical sums of money now required for reconstruction could have been drastically curtailed, if not altogether avoided. We all know that prevention and mitigation pay and yet it is unfortunate that those at the helm of affairs still prefer to pay for the end-of-the-pipe solutions from the public funds at the expense of the basic human needs.

By not taking recourse to the prevention and mitigation route, contrary to the stated policy, even the Central Government does not do justice with its own commitment to the people of India made in the National Disaster Management Act of 2005. The Act, which was enacted about the same time as the last Chennai flood disaster of December 2005, had promised to the nation a paradigm shift from the relief-centric approach to the culture of prevention and mitigation. With ten years of lead time since the last major flood

disaster, the State Government was expected to feel the pain of disasters and take the Act more seriously.

Another stated strategy of the Government of India is to shift the focus from development to *sustainable* economic development. The Five Year Plan clearly mentioned that the planned expenditure on disaster prevention and mitigation will be coupled with the Calamity Relief Fund. There was a major shift of Focus in the XI plan which laid emphasis on integration of disaster mitigation with development planning. If the government would have taken its own strategy seriously, the severe flooding of the areas surrounding Perumbakkam because of the construction of the IT Corridor on the filled-up lake could have been avoided. The flooding of Mudichur, Velachery, and several other areas are not a matter of surprise to those who Chennai because they had encroached the wetlands and the river basins. The city's largest mall, Phoenix, is on a lake-bed — Velachery. In 1976 floods too, Adyar over-topped its banks invading houses by several feet precisely because of the stream encroachment.

There is no denying the fact that for economic and infrastructure development, land has to be found. The national challenge lies in using the land in a manner that construction and mitigation measures are planned, designed and implemented as a single package. This should have been done when the major bus terminal was built in the flood-prone Koyambedu or when the Chennai airport was built on the floodplains of the River Adyar. Building a Mass Rapid Transit System over the Buckingham Canal and several automobile and telecom SEZs and many housing estates, over the erstwhile water bodies, were less of engineering in development and more about the recipe for a disaster. By hindsight, it seems clear that the government should have walked the talk by integrating disaster mitigation with planning for sustainable development. Reportedly over 300 water bodies have already been lost to urbanization and construction. The 16 tanks belonging to the Vyasarpadi chain downstream of Rettai Eri have reportedly met with a similar fate.

All the blame cannot be placed on either the Government or the Extreme Weather Events. We the people are equally responsible for our compromising positions when it comes to our self-interest. Often times, we pressure administration for bending of rules and regulations for our narrow gains. According to a report submitted by CMDA to the Madras High Court, there are over 1.5 lakh illegal structures in the city, hazardous also to the city drainage. When High Court ordered demolition, the people appealed to the Supreme Court and sought stay-orders. Naturally, we need stricter laws and swift disposal of such cases. It is high time people realize that disasters drain our resources, sap our strength, halt the pace of economic development, rob the posterity of India's cultural heritage and inflict lifelong suffering on the victims, especially in the low-income group.

Those responsible for the above acts of omission and commission must be held accountable not only for what wrong they did, but also for what they should have done, which they did not do. The professionals who implemented the above projects were responsible for ensuring that the projects themselves do not become a cause of disasters.

Since it is not in our culture to fix accountability, the civil administration, on the predicted lines, did pre-empt inconvenient and hard questions about public safety by declaring the Chennai 2015 floods as a natural calamity and placed the blame entirely on unprecedented rainfall due to Climate Change, completely ignoring the interplay of numerous other causative factors. The Tamil Nadu Chief Minister, even without any investigation, reportedly said "Losses are unavoidable when there's very heavy rain. Swift rescue and relief alone are indicators of a good government."<sup>1</sup> Earlier also, the Chennai floods of 1969, 1976, 1985, 1996, 1998, 2005 and 2015 were attributed to the heavy rainfall events. Does that mean that factors such as unrestrained and unplanned urbanization, non-engineered and illegal construction, encroachment of water bodies and low-lying areas had no role to play? It is true that the heavy rainfall forced authorities to release 30,000 cusecs from the Chembarambakkam reservoir into the Adyta river over two days, causing flooding and submergence. But the question to ask is why such situations could not have been anticipated and provided for in project design? How can one explain the flooding of Koyambedu and the neighbourhood other than by concluding that the related storm water drain projects failed to account for the built-environment, the altered urban landscape and the water logging data of the previous cataclysmic flood events?

It is only when the authorities ignore such ground realities and try to hide behind the Extreme Weather Events as the sole cause that we keep working in the comfort zones of business as usual, take recourse to the obligatory post-disaster relief-centric approach when needed, and keep re-reaffirming our faith in the merit of disaster prevention and mitigation, as parrots do.

There are no simple solutions to the problems of flooding in the city of Chennai which have been allowed to develop over the period of many decades. Instead of overlooking the wrong doings of the past and throwing blame on heavy rainfall, the political masters, bureaucrats, professionals, the civic officials should come out of the denial mode, own the responsibility and concede with humility that they have failed to walk the talk. It is time to learn from the past experiences and put institutional mechanisms and Standing Operating Procedures in place to ensure that disaster mitigation measures get firmly embedded in all the future project designs.

---

<sup>1</sup> A NDTV

The large scale flood hazard maps and hydrology maps of the City of Chennai should be revised on priority. The corresponding large scale maps should clearly mark problematic areas, buildings and infrastructure at risk. These maps should guide the revision of the second Masterplan prepared by the Chennai Metropolitan Development Authority. Both, the hazard maps and the Masterplan should be independently peer-reviewed, and thereafter the future flood risk scenarios should be projected with sensitivity to Climate Change, highlighting the problem areas in the backdrop of the experiences gained during the December 2015 flooding. The National Guidelines on Flood Management issued by the National Disaster Management Authority in January 2005 would need revision and adoption, *mutatis mutandis*.

All the illegal constructions should be demolished by expediting pending court cases.

Extreme Weather Events and heavy rainfall are going to be matters of concern all the time and should not ever be taken as unforeseen happenings. The extreme rainfall events like the one which pounded the State of Tamil Nadu and triggered the catastrophe will have to fully accounted for while formulating preventive and mitigation strategies. Modern technologies should be deployed to improve weather, rain and flood forecasting.

India has an ambitious blueprint of economic development and one of the high profile programmes is development of Smart Cities. Ponneri of Tamil Nadu has been identified for development as a Smart City. Hopefully, those responsible for its planning carefully study why the airport was closed and several iconic companies had to shut their operations. The functioning of giant software exporters like TCS, Infosys and HCL and automobile giants like Renault Nissan, Yamaha, BMW and Ashok Leyland were also badly affected by the floods. In the fiercely competitive world with international commitments, India cannot afford the repeat of such sad experiences ever again in future. An empowered High Powered Committee should be constituted to approve the plans of Ponneri, and be accountable to the nation.

Because of the flood catastrophe, leading newspaper, The Hindu was not published for the first time since its inception in 1878. Future Quiz competitions in the schools of Tamil Nadu will make sure that the younger generation remembers the Catastrophic Chennai flood of December 2015 at least for this reason. The Prime Minister of India gave a post-disaster package of Rs 1940 crore against more than Rs 5000 crore sought by the State Government. Why not think of a mitigation package of Rs 20 000 crores to put a lid on such disasters forever and live happily thereafter!

# Frontiers of Hydrocarbon Business – Molecules to Markets – One Perspective

Ajit V Sapre

This paper gives a scientific perspective on the hydrocarbon business that provides energy and materials to the modern society enabling a higher standard of living. It illustrates how the application of fundamental science solves business problems and creates societal value.

Virtually all of the fuels, chemicals, and materials used by modern society are produced through chemical transformations. Chemical Reaction Engineering (CRE) plays a pivotal role in bringing molecules to markets in this value chain. Beginning from the fundamental science of molecular understanding, chemical transformations moving through process level engineering and culminating into plant and system level integration, CRE enables the value maximization of molecules through the technology chain (see Figure 1) to the point of enterprise value realization via commercialization.

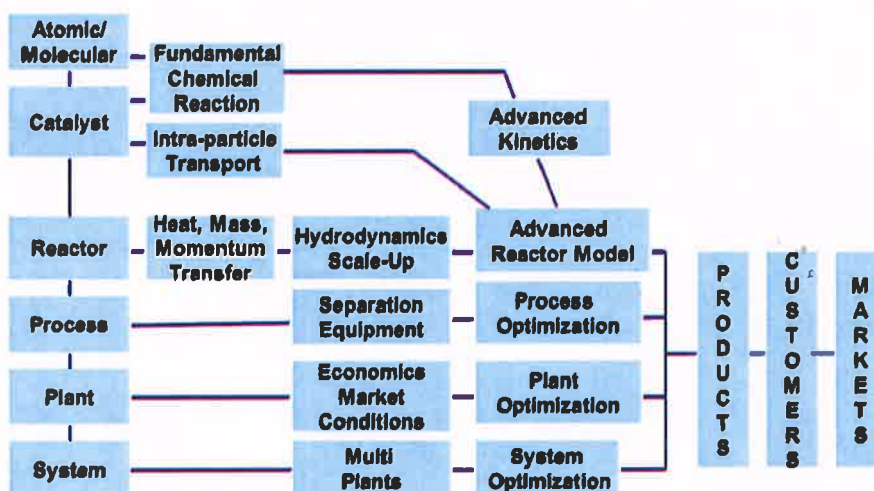


Figure 1: The technology chain to move molecules to markets through fundamental scientific/technological advances.

This paper reviews some of the work performed by the author in some critical technology areas in his career, which demonstrates how science can be converted to practical solutions that created commercial differentiation for some aspects of the hydrocarbon business.

## Catalysis

Mobil was the first in the world to develop and introduce proprietary ZSM-5 as an additive in FCC units in the mid 80's to increase gasoline octane. The chemical transformations take place at molecular level in zeolite pores, which are at angstrom level. Mobil's intellectual property in zeolites for hydrocarbon transformations dominated this scientific field for decades. Today ZSM-5 additive is primarily added to increase propylene yield, a more valuable product, at the expense of gasoline. Increasing propylene production is important to develop variety of downstream products including polymers to meet growing demand from developing economies. Recently Reliance has developed a more active and stable ZSM-5

additive with a proprietary development. This development will increase 0.5% in propylene yield in each FCC, i.e., additional propylene of ~150 T/d, from the two FCC units, compared to the available commercial ZSM-5 additives from various suppliers.

### Kinetics or Rates of Chemical Transformations

As an example of the importance of kinetics let us look at the methanol to olefins (MTO) process, developed in early eighties. This process produces primarily ethylene and propylene, the building blocks for the plastics industry. Novel experiments that varied space velocity to maintain constant reactor outlet conversion to compensate for catalyst aging were done to simultaneously study the kinetics and catalyst aging, for methanol to olefins (MTO) process in early eighties. Using the variable space velocity, aging and conversion kinetics can be decoupled (see figure 2). This accurate decoupling of conversion kinetics and catalyst aging enabled accurate prediction of cycle length for fixed and fluidized beds using the same kinetics parameters (Sapre, CES 1997).

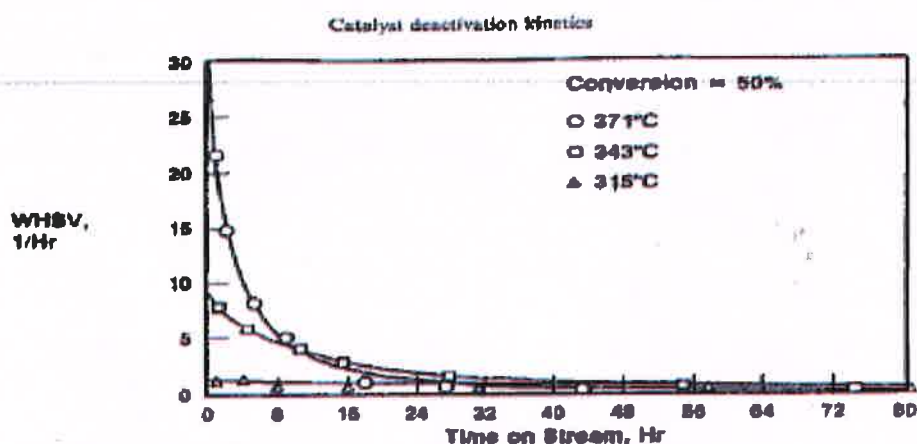


Figure 2: Weight hourly space data versus time on stream. (Sapre, CES 1997)

Methanol to olefins is an unusual reaction involving acceleration of methanol conversion due to autocatalytic effect of first formation of olefins. Interaction of autocatalysis and particle diffusion can lead to several unusual phenomena (see figure 3). We took advantage of this interaction to demonstrate that bigger particles lead to smaller reactor volumes. The autocatalysis also leads to reactor run away, multiplicity and oscillatory behaviour over certain operating parameters. Contrary to prevailing theory, these were unusual and unanticipated behaviour for a commercially important MTO reaction. In order to understand the fundamentals of autocatalysis/diffusion interaction we developed first principles theory that accurately predicted rate enhancement as well as reactor stability and helped optimize reactor design and scale-up.



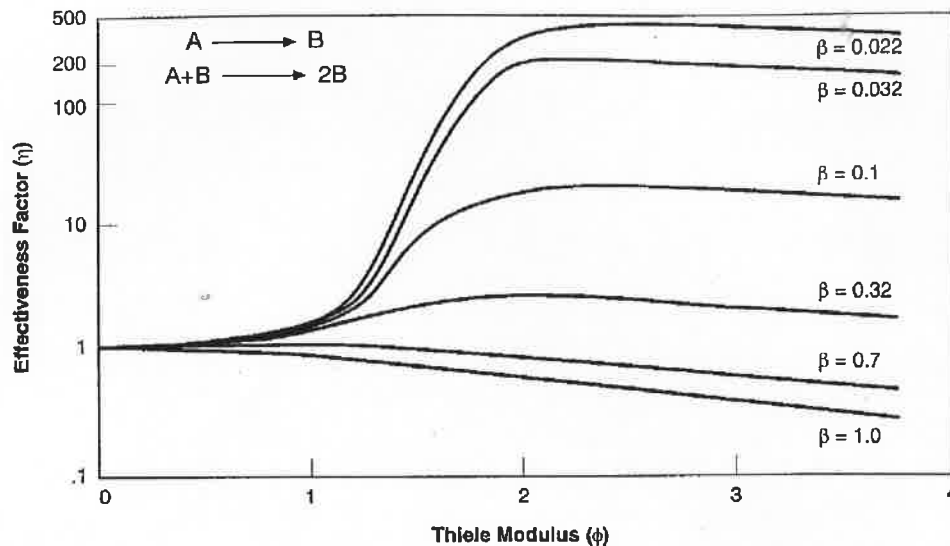


Figure 3: Particle effectiveness factor curves for quadratic autocatalysis. Here, effectiveness factor ( $\eta$ ) is the ratio of integral average reaction rate of A in particle to reaction rate of A at surface conditions; and  $\beta$  defines the relative rate of the first reaction to the second reaction at zero surface concentration of B. (Sapre, AIChEJ, 1989)

Another major breakthrough was the detailed kinetics of complex mixtures such as crude oil. Molecular fingerprinting of crude oil (several hundred thousand molecules) is now possible with modern analytical technology. Feedstock is one of the largest contributors to operating cost and we need to maximize value of every molecule. Such rigorous representation of feedstock composition improves kinetics and product property predictions that improve accuracy of business decisions from planning to control.

As an illustration let's look at how kinetics of fluid catalytic cracking (FCC) process has evolved in the last fifty years. The kinetics representation of processes has evolved from simple 3 lump model to 10 lump model (see reaction network for FCC kinetics in Figure 4) to about 50+ lump models. In Mobil we developed a new approach called structure oriented lumping, which is essentially a molecular level representation of kinetics for complex mixtures involving thousands of molecules, typical of crude oil. With this methodology the kinetics can now be represented by group contribution methods, similar to thermodynamics. Such molecular group contribution models are significantly more accurate than lumped models creating enormous value, which is a major contribution to the field of kinetics.

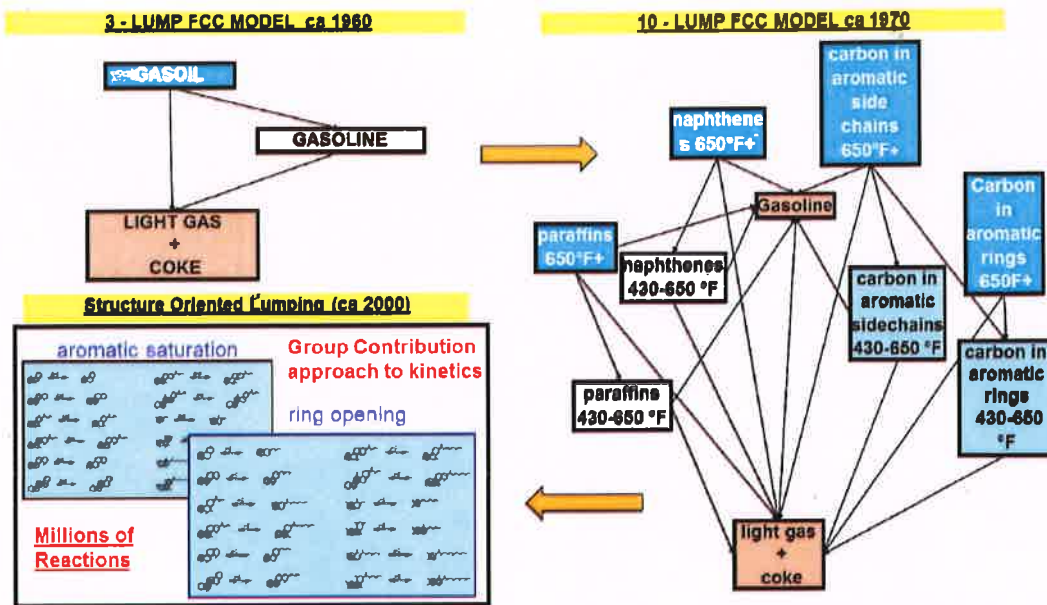


Figure 4: The evolution of FCC reaction kinetics modelling. Molecular composition models provide more accuracy than lumped models (Sapre, Kramback, 1991).

Group contribution type approach to kinetics is allowing accurate representation of chemical transformations, resulting in molecular representation of product streams, which allows accurate product property predictions. This approach eliminates traditional approach of correlative models, e.g., gasoline octane determination using engine test data. Now the composition models allow accurate prediction of such properties from individual molecular octanes. Impact on profitability of this approach when integrated with planning for crude selection and processing in refineries with advanced process control, real time optimization and rigorous planning scheduling tools is hundreds of millions of dollar per year for a large oil and petrochemical giant like ExxonMobil.

## Reactor Design

We developed a rigorous theory comprising of constitutive equations to describe solids flow patterns in a dense fluid-bed FCC regenerators to help optimize regenerator performance. The key parameters of the constitutive equations were fitted with data obtained from probe measurements in operating commercial units. Integrated fluid mechanics models with coke burning kinetics allows to optimize the air grid design to match air flow with catalyst circulation patterns (see figure 5). This first principles approach helped improve the performance of commercial units by decreasing NO<sub>x</sub> by ~30% as it reduces after-burn. Also this design modifications increased the coke burning capacity by ~5%, and catalyst circulation, improving the overall FCC performance.

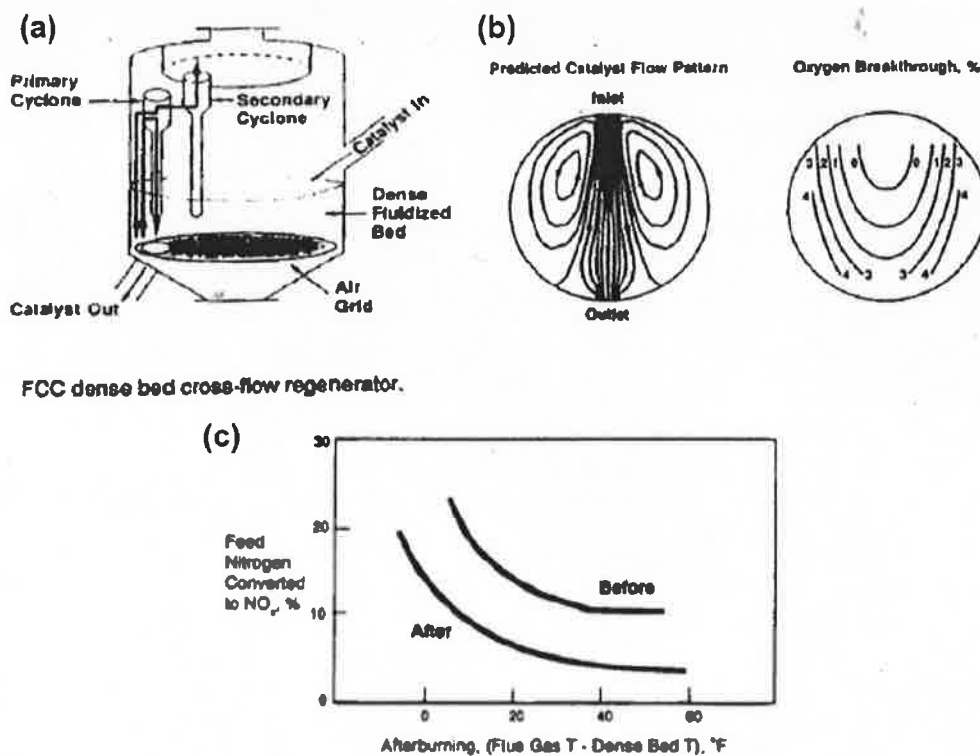


Figure 5: (a) FCC dense bed cross-flow regenerator, (b) oxygen breakthrough in cross-flow regenerators, and (c) improvement in performance as demonstrated by reduction in feed nitrogen conversion to NO<sub>x</sub>. (Sapre, Leib & Anderson, CES 1990)

Trickle bed reactor is the most widely used reactor system in the oil industry. We developed novel flow distribution measurement probes and installed them in large-scale commercial operating units. The results of our study showed significant point to point variation in liquid flow distribution. Our study also showed increase in non-uniformity of liquid flow moving down the reactor. Most significantly, contrary to popular belief, severe mal-distribution persists at high mass flow rate, e.g., so called pulsing flow regimes, and resulting poor process performance. Even today most commercial reactors are designed to operate in pulsing regimes with associated high capex and opex. We developed fundamental hydrodynamics models for multiphase flow by borrowing concepts like relative permeability, saturation and capillary pressure from upstream business (oil and gas reservoir models). The reservoir models flow patterns are typically at low Reynold's number, we extended this theory to turbulent flows typical of commercial trickle-bed reactors. We used the commercial and pilot plant data to fit the constitutive parameters. With this knowledge we developed, one of the most cost efficient reactor designs (lowest capex and opex design) and implemented them commercially.

The performance improvement of the newer trickle bed design is shown in Figure 6. We fixed the efficiency from poorly performing design from 50% to almost perfect, close to 98%. In fact, commercial reactor process performance was better than the pilot plant.

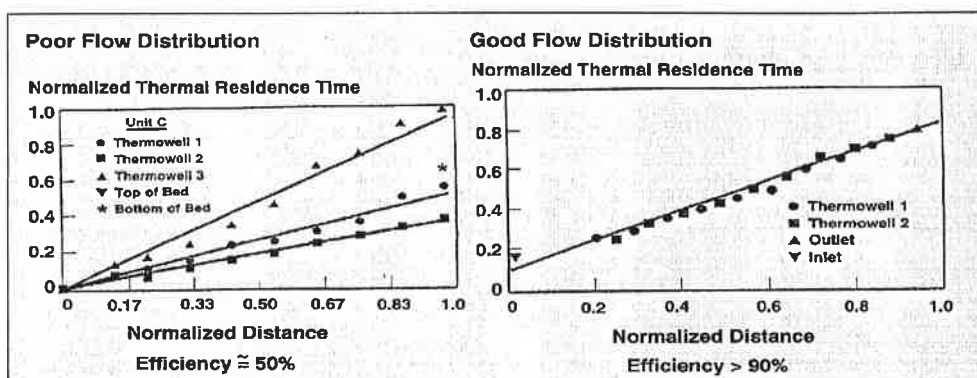


Figure 6: Fundamental understanding of phenomena on large scale system leads to significant performance improvement and efficient cost-effective reactor designs (Sapre & Katzer, I&EC Res., 1995)

### Process Technology

TransPlus is a process and catalyst to trans-alkylate heavy aromatics, that otherwise go to fuel, to high value P-xylene, a key raw material for polyester production. In less than three years, we took this process from lab to commercial scale operation to maximize P-xylene. We were the first to develop and commercialize a trans-alkylation process in mid-nineties. Today several other licensors offer similar technology.

Another process innovation is a rapid cycle hydrogen purification process (RCPSA) that also involved development of a novel hardware. This technology development is an example of process intensification, where we reduced the size of the plant by almost a factor of 50. Rapid Cycle Pressure Swing Adsorption (RCPSA) offers a more compact, less expensive, and more energy efficient solution for H<sub>2</sub> recovery compared to conventional Pressure Swing Adsorption (PSA) technology (see figure 7), used commonly in the industry. We

implemented this process commercially in France in 2007 and it won the coveted R&D 100 award in the USA in 2007.

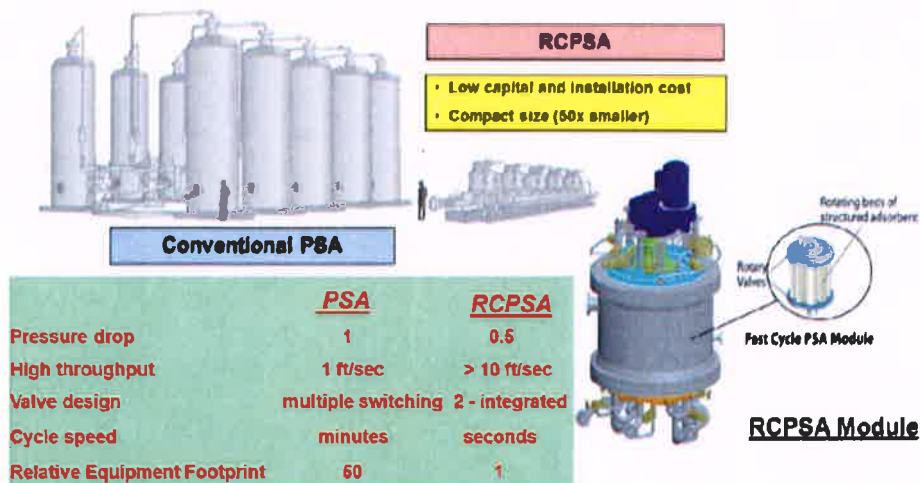


Figure 7: Rapid Cycle PSA (RCPSA) commercial unit. Winner of R&D 100 award, in 2007

### Plant Integration

Although advanced control and real time optimization tools have improved manufacturing performance over the years, these systems are an integration of several legacy systems. There is a significant opportunity to conceptualize step-change in optimization/control, both off-line and on-line using more rigorous tools. Optimization and control needs to be event driven to fully exploit manufacturing assets, and to fully sweat the assets. Here is an example of how we improved the performance for a utilities system (steam and power production).

The generation of steam and power required for the operation of a modern refinery is a significant operating cost – almost 10% of crude processed. We automated the entire power plant operation by developing a rigorous non-linear model for every piece of equipment and essentially automated with minimum operator involvement. Both non-linear programming and mixed-integer non-linear programming tools were employed and they replaced the legacy linear programming optimization technique. The results of this change are shown in figure 8, where top line is plant performance before the system and the bottom line is after the system was installed. We realized approximately 3-4% savings in fuel consumption amounting to a significant cost reduction. This system was named OPTIMUS – optimization of utility systems.

We also did a lot of work for the upstream oil and gas business. We were the first to integrate reservoir models with surface processing facilities and made significant progress towards developing fully integrated enterprise wide modelling tool. A software tool that integrated surface facilities with reservoir simulation was called OPTINET and used extensively to optimize tertiary oil recovery in Bakersfield, California. This increased tertiary oil recovery by 2-3%, reduced steam flooding, and extended the life of the oil field.

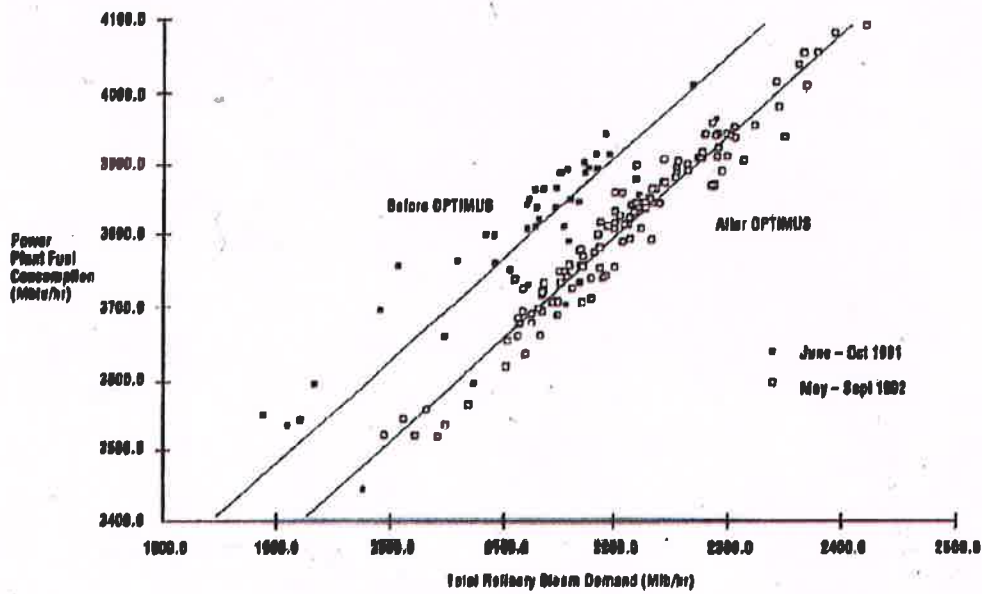


Figure 8: OPTIMUS: Improved performance at Beaumont Refinery with reduced fuel consumption (Wellons, Sapre, NPRA, 1984)

Figure 9 shows an enterprise wide optimization scheme increasingly possible with the help of technical computing with an expansive knowledge management framework.

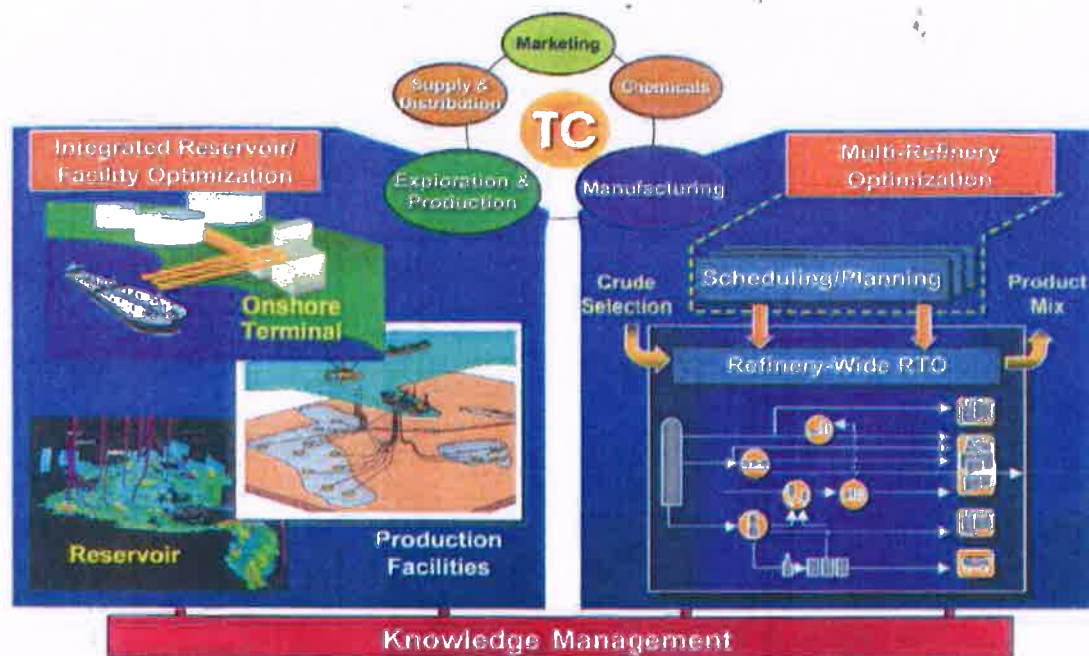


Figure 9: Application of knowledge to improve business in real time. (Katzner, Ramage, Sapre, CEP 2000)

Today, we have embarked upon end to end manufacturing digitization through world-class scalable IT backbone. Four key elements of this strategy are (i) process automation; (ii) cloud computing; (iii) mobility and usability; and (iv) big data analytics. The objective is to create a real time, online, integrated, connected, agile self-aware asset management system. In the near future, every industrial company will be a software company to create most value through access to massive real time data, and taking smarter business decisions.

### Systems Analysis

One of the most challenging problems of our time is to develop alternative feedstock for the energy and hydrocarbon industry. The fossil fuel rich path taken by the developed world for its growth is not sustainable in the long run given the environmental constraints that the world faces now. The rest of the world, especially India, has the opportunity to leapfrog the developed world by adopting more sustainable energy technologies such as wind, solar or biomass (see figure 10). Integrating new streams of energy and feedstock with the existing infrastructure is an ideal system level problem.

One promising biomass energy resource is algae that convert  $\text{CO}_2$  and sunlight into oil. Algae have the highest productivity. With rapidly advancing biotechnology, it is likely to lead to a commercial viable option in the near future, which may make India self-sufficient in liquid hydrocarbons. It is a reaction engineering problem, essentially multiplying reactors or algae cells, in a cultivation system or a large pond. The challenge is the efficient scale-up of biological systems to large scale industrial applications. However, we are making steady progress in unravelling the mystery of photosynthesis and increase overall sunlight to biomass energy productivity significantly.

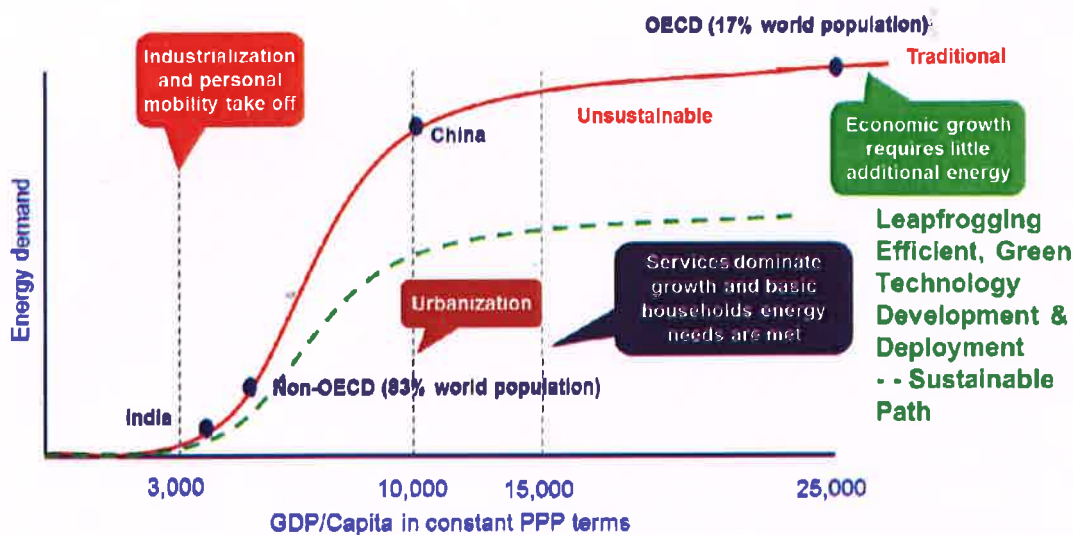


Figure 10: Demand for energy is growing rapidly as countries like India enter the most energy-intensive phase of economic development.

## Conclusions

The boundaries between what we know, understand, and can quantify and what we cannot yet adequately quantify defines the frontiers. As the technology chain matures and we solve the problems, there are advances in frontier areas at all levels. It leads to closer integration of fundamentals from the molecular level through to the system level optimization creating societal value through life enriching projects.

The global drivers of environmental sustainability and providing growth opportunity to the 80% of the world population living in the developing countries demand a paradigm shift in the direction we require to shift the frontiers of science and technology. In the context of India, where we have a challenge of improving quality of life across entire socio-economic spectrum, in agreement with the motto of the current government – Sabke Saath, Sabka Vikas, “inclusive innovation” that will create affordable excellence is the call of the day for scientists and engineers.

It will require a concerted effort across the boundaries to cater to the diverse needs of the nation- food, infrastructure, healthcare, material and energy needs of the masses, automotive, defence and space. We should aim to achieve “affordable excellence”. Industry excels at execution and research institutions excel at creativity. We must intertwine our resources to help India leapfrog into the future, with a collective mandate: Science for Solution; Technology for Transformation; and Innovation for Impact.

“I would prize every innovation of science made for the benefit of all” – Mahatma Gandhi

## References

Katzer, J.R., Ramage, M.P., Sapre, A.V. (July 2000). Petroleum Refining: Poised for Profound Changes. *Chemical Engineering Progress*, 41-51



Sapre, A.V. (1989). Diffusional Enhancement of Autocatalytic Reactions in Catalyst Particles. *AIChE Journal*, 35 (4), 655-657

Sapre, A.V. (1997). Catalyst Deactivation Kinetics from Variable Space Velocity Experiments. *Chemical Engineering Science*, 52(24), 4615-4623

Sapre, A.V., Leib, T.M., Anderson, D.H. (1990). FCC Regenerator Flow Model. *Chemical Engineering Science*, 45 (8), 2203-2209

Sapre, A.V., Katzer, J.R. (1995). Core of Chemical Reaction Engineering: One Industrial View. *Ind. Eng. Chem. Res.*, 34, 2202-2225

Sapre, A.V., Kramback, F.J., eds., (1991). *Chemical Reactions in Complex Mixtures*. New York: Kluwer Academic Publishers

Wellons, M.C., Sapre, A.V., Chang, A.I., Laird, T.L. (1993). On-Line Power Plant Optimization at Mobil's Beaumont Refinery. NPRA Computer Conference Nov 15-17, 1993

## An Academic's Approach to Professional Problems



**Subhash Chander**

Approach to work depends on the environment in which you are brought up. In my youth I have seen many of my countrymen from earlier generation sacrificing their careers and devoting their life for the cause of freedom from British rule. Their sacrifices created an urge in my generation to work to improve life in India after independence. We were given opportunities to gain technical knowledge on highly subsidized tuitions fees, hostel accommodation and other facilities. The times highly motivated us to make a mark and gain knowledge to solve the problems facing the country. Engineering education focuses on problem solving and it aptly matched my own determination to gain in depth knowledge and build knowledge base useful in the solution of problems in the area of water resources. The Water Resources group at IIT Delhi, which, I joined in 1961 encouraged professionals from Government organizations to discuss their problems and use our knowledge base to find solutions. In the next Paragraphs, I will discuss some cases to show how our mind worked to find solution to the problems using latest tools/analysis and synthesis in Hydrology/ Hydraulics.

### 1. Design of cavitation free transition for Sutluj-Beas link

The Bhakhra- Beas Board was seized with the problem of designing a transition from a circular section to a rectangular section supported on piers for Beas- Sutlej link. The Board had approach the best Laboratory in the India to suggest shape of the nose of piers, so that negative pressures do not develop in the area and damage the piers. The laboratory is famous for testing designs using hydraulic models. The report was examined by us in IIT. The Reynolds number which governs flow in closed conduits was calculated for the model. Its value was  $1/25^{\text{th}}$  of that of prototype. Therefore, it became evident that shape of piers in the model derived at low Reynolds Number was not likely to work without cavitation. A suggestion was made to test the model in wind tunnel at 15 times the Reynold number of the hydraulic model and see whether changes are required to ensure cavitation free design. The Board accepted the proposal and experimentally determined shape of piers supporting the roof was provided to the Board. The model was  $1/25^{\text{th}}$  of the size of Prototype. After determining the shape of the piers ellipses were fitted on either side of the piers and instead of supplying the engineers the coordinates of the nose curve from the model as multiplying them would have magnified the errors in measurement. The major and minor axes of the ellipses fitted to experimental data were given in the report. Before supplying the results model was remade using the calculated coordinates and found to work without generating negative pressures. The Board discussed our report and accepted the shape suggested by us. The structure is operating for the last 40 years without any cavitation even with an imperfect assumption and determination of shape of piers at a much lower Reynolds number. The engineers told us that fitting of ellipses helped them to precisely obtain the curved shapes for the nose of piers producing a streamlined shape.

## 2. Real-time flood forecasting of levels of Yamuna river at Delhi

In 1971, Central Water Commission was using Gage to Gage correlation to forecast the flood levels at Delhi. The problem was to forecast the levels as flood levels start rising at Delhi till the time flood recedes to a level below the danger mark. The past data was analyzed to understand the formation of floods in the river and it emerged that a simple reservoir and time delay could describe the formation of flood wave in the catchment using the input hydrograph data at an upstream point. Different alternatives methods could be better to solve the problems, is the underlying concept in this case.

The time delay was found using the travel time between the upstream point and at Delhi Bridge and reservoir characteristics were obtained from the past data. The model was tested by the Engineers in Central Water Commission by forecasting a flood in 1971 Monsoon. There was a good match between the observed and forecast values and the time for which the flood was above the danger mark at Delhi. The model was a behavior model and was imperfect to the extent that time of travel for various floods would vary between the upstream point and downstream. But it paved the way for useful interaction with the premier agency to upgrade their river forecasts on all India basis.

## 3. Location of hot water outlet in a man-made reservoir at Korba in relation to inlet point of water for cooling purposes in a thermal power plant

The problem was to locate the outlet so that hot water from the thermal power plant gets cooled by evaporation by the time it reaches the inlet point. The Engineers wanted that we make a 1/25 scale model of the system in IIT and show that hot water cooled before it reached the inlet. The cooling had to take place by evaporation from the water spread of hot water as it travelled from hot water outlet to the intake point. In actual reservoir in the field it was found that at different sections nearer to intake the water on the surface was hotter as compared to water at the bottom of the reservoir. When we took temperature measurement on the hydraulic model the water next to the bed was found to be hotter than at the surface. The 1/25<sup>th</sup> scale model reduced the depth of the reservoir to 1/25<sup>th</sup> of the depth in the prototype and the sun rays penetrated the water depth in the model to heat the bottom surface which in turn heated the water. The model was abounded and problem was split in to two sub-problems. First problem was the determination of area of reservoir surface which takes part in the evaporation to cool the hot water between the out let and inlet. The second problem was to develop a mathematical model using Energy balance approach to forecast the temperature reduction for various ambient temperatures, relative humidity, wind speed, and water temperature. The area was determined for an outlet inlet configuration, which gave the area required to cool the hot water in the hottest month of May each year. The experiment to determine the area for various inlet-outlet configurations was carried out in a flow visualization tank. A co-axial diagram for computing the inlet temperature using climate variables was provided to the thermal plant for adaptive management of cooling in the plant for the suggested configuration of inlet and outlet for various ambient temperatures using the mathematical model. Three dimensional problem in this case was split into two problems and an approximate approach was used to find solution to meet the deadline.

## 4. Spacing of embankments on both sides of the River Yamuna so that Delhi is not flooded if 1978 flood reoccurs in the Yamuna Basin

It took three days of active consultation with the engineers of Central Water Commission to define the deliverable by IIT. It was decided that IIT will prepare a report showing the impact of various spacing of the Embankments on water levels at Delhi Bridge, for the passage of 1978 flood wave in the basin. The gauge data available with the commission along the river as 1978 flood breached the existing

embankments was supplied to IIT. IIT formulated a conceptual model of the river reach and developed a new methodology in three months to answer the question. Recommendations were also made to get one foot contour survey of the Yamuna flood plain so that we could use St. Venant equations to recalculate the results for comparison with the new methodology. We repeated the work when survey data was made available to us after two years and found that the earlier work gave as good results as the established methods we used after the data were made available. These results were used to determine the water way and foundation depths of all bridges constructed on River Yamuna in Delhi state and to rebuild the embankments from Kalanaur to Delhi. This again illustrates the point that engineers need quick answers and are willing to accept reasonable assumptions as long the results are validated.

#### 5. Impact of forests on floods in Ramganga

The impact of catchment treatment and tree planting by Forest department of U.P on floods in Ramganga river basin on the basis of hydrological/ hydro-meteorological and data on treated portions of the basin was an other interesting problem. One of our PhD students decided to work in this area and collected hydrological, hydro-meteorological and catchment treatment data. After analysis of the data it emerged that catchment treatment has no effect on floods of 50 years and higher return period. Given the monsoon climate and topography in this area, low flows in the river decreased during low rainfall periods. These were controversial statements. Most people believed that floods in rivers decrease because of forestation, and flows increase in dry periods. Our conclusions were explained by drawing the attention of the forest officials, that the soil absorbs low intensity rainfall as infiltration capacity of the soil is greater than the intensity of rainfall thus decreasing surface runoff. During the rainless periods the new plantation transpires the water in the soil emptying it for next rain. However, during high intensity rains which are usually preceded by low intensity rainfall, the soil is saturated and it has practically no effect on floods higher than 50 year flood. Our conclusion is supported by the historical fact that this region has faced catastrophic floods in last weeks of August and first week of September when the catchment is saturated by rain in the earlier periods. It also emerged from the study that plantation in central portion of the catchment can increase the intensity of floods. The reason being, that delay time of runoff increases due to plantation in middle reaches. The runoff from this area, in some cases matches with the arrival time of flood from upper catchment thus increasing the flood intensity just downstream of middle catchment. In this case data was analyzed to bring out the impact of treatment of the catchment. It required a number of meetings with the agencies to convince them that each catchment/ basin is different and its behavior is a function of topography, geology and hydrology and results cannot be generalized.

#### 6. Creating an interactive simulation model for Lago-di -Trassimino Perugia Italy for developing solutions to improve tourism in the lake area

This problem was identified to help the environmental and tourism department as well as the local administration to improve the foot fall of tourists in the area to boost the local economy. This required that the lake has sufficient water during the tourist season so that all recreational facilities on the lake are operational. It was decided to augment the water in the lake from adjacent basins. The problems posed was to develop a simulation model of the lake so that the quantum of augmentation is decided. Thirty years of data of lake levels was available to check the validity of the software which was designed at IIT and delivered to Hydraulics department of Perugia University, our clients to develop a project report for funding to the government in Rome.

The experience I gained in solving problems for the diverse groups helped me to coordinate the implementation of computerization of administrative functioning at IIT Delhi. The stakeholders were, the IIT administration which funded it, the average worker who had to use the application, technical group whose advice I sought to develop the infrastructure, technical committee ably supported by Administrative computerization support service, consisting of software professionals and chaired by Head computer centre who coordinated the design of software with the consultancy firm, the humanities department which planned the training of the staff and the one page support pamphlet for each desk in the sections. It is heartening to note that the application is fully operational in IIT since last 20 years and has been updated over time by including new rules and procedures.

#### 7. Disposal Of silt from balancing reservoir in Bhakra Beas Sutluj Link

The following cases pertain to the period, after my superannuation from IIT Delhi.

The problem arose in Himachal Pradesh, because of pumping of silt slurry from balancing reservoir to a natural stream between the balancing reservoir and the river Beas. The silt settled in the stream. During high intensity rain the stream overflowed its banks and flooded the agricultural area, depositing coarse silt and ruining crops. I was invited to join as non-official member of the committee constituted by the court for suggesting a suitable solution to solve the problem. The solutions on the table ranged from a pipeline to carry the silt from balancing reservoir to either the river Beas or Sutluj. After lot of discussion, the colleagues on the committee agreed to use the hydrological characteristics of the stream to solve the problem. The innovative solution was to pump the silt whenever the flows could carry the silt in the stream to the river to a level when it starts flooding the adjoining agricultural lands. A Communication system was set up on the stream, nearest to flooded area to communicate levels in the stream to the dredging party to enable them to start dredging and pumping silt within the specified levels. The court accepted the solution and requested the committee to monitor the functioning of the solution for next two years. The system is functioning to the satisfaction of all parties saving money and installing a system which constantly monitors the applicability of solution.

#### 8. Quantitative analysis for equitable distribution of water between Riparian States of The Krishna basin

I joined Interstate water resources Andhra Pradesh as a senior consultant in 1997 to assist the state, before the Tribunal which was set up to allocate water of the river Krishna between riparian states. My terms of reference were, to assist the Legal, Technical and Administrative teams to create the basis on which the state of Andhra Pradesh could logically present their case before the Krishna Water disputes Tribunal II for equitable distribution of water between the Riparian states. The riparian states are Maharashtra, Karnataka and Andhra Pradesh. After assessing the availability of data, it emerged that the utilization data which is needed to develop a virgin time series were not available on monthly basis to A.P from upper states. Annual utilizations for the state and cropping patterns in the basins was used to determined utilizations required at appropriate time scale. Rainfall data was obtained for all the IMD stations within the Krishna basin. The density of rain gauges were augmented in various sub-basins with time. For example, there were 10 rain gauges for first 10 years, they were increased to 20 for the rest of record. In such cases rainfall to rainfall regression models for the common data time interval was used to homogenize the data. It was decided to determine the water availability in the 12 sub-basins of River Krishna on monthly basis for the sub-basins using measurements on the river at central water commission data stations and rainfall data from IMD. The strategy employed was to use measured data after validation using standard methods. The utilization data on annual basis was used to develop annual time series for all the basins, and water generated by each state was determined. Since

all these basins contribute to flow at the terminal point of Vijayawada, the contribution of each sub-basin was suitably modified so that annual contributions from sub-basins match the virgin flows at the terminal point. These annual flows were divided using gauged flows at central Water Commission stations into monthly flows. A multiple reservoir simulation Mike Basin model was used to determine how the projects were impacted in the state of Andhra Pradesh because of allocation by the previous Tribunal and additional allocation to Upper States. I filed an affidavit as an expert witness on behalf of state of Andhra Pradesh on water availability and impact of allocations upstream on A.P in 2008. I was cross-examined for over three months by the other states on the Issues identified by the tribunal to determine the new allocations to various states as well as to address their concerns on my statements in the affidavit and conclusions. The affidavit was based on whatever data was available with the state of Andhra Pradesh and paved the way for the tribunal to introduce quantitative methods to address the issues. The states were asked to supply latest data. CWC provided the expertise to the tribunal with two assessors and other engineers to work out the water availability with the new data available with the tribunal. It is heartening to note that my affidavit set a precedent to use quantitative methods in the allocation of water between the states keeping principles of equity, hydrological factors, demography, and riparian rights in mind. A major recommendation accepted by the tribunal was to set up a Board with adequate powers to implement the decisions of the tribunal with online data exchange from projects to make the process of utilization by various projects totally transparent.

During my dealings with the engineers since 1968, I find that they are devoted to find creative solutions to the problems in hand and are result driven. Usually the problems are under or over specified and need to be diagnosed. Deliverables can only be defined after assessing the data available with the organization. The methodologies to be followed are identified. Professional's time frame is more or less immediate; therefore, standard software to analyze the problems is preferred. The solution is found using the identified methodologies and checked with other formulations using simplified assumptions. The result is evaluated to see whether it matches the observation in the field and can be explained to a logical group. Otherwise, new methodology such as the one described in the inlet outlet case is evolved. The results are presented as per the deliverables and should be in a format which helps them in implementation. Fitting of ellipses to the nose of piers instead of coordinates of experimental data helped considerably in implementing recommendations. Mathematical/ conceptual models or simulation models help immensely in solving hydrological problems quickly and ensure that law of conservation of mass is not violated in the computation processes at all junction points.

The data availability decides the methodology, deliverables and the choice of model. Models help to develop consensus between diverse group of stakeholders involved in real life situations. The impact of conclusions reached in the Krishna case was determined by the riparian states using data in my affidavit, and I was interrogated with their interpretation for weeks to demolish or accept the line of reasoning. Such an approach brings transparency to the decision processes, a boon in multi stakeholder groups for consensus building. They also help to build confidence in the accepted solutions. The underlying concept followed by us as engineering academics in all above cases as well as others I had the good fortune to be associated with is, that different or alternative methodologies are better even though our understanding of the physical processes that were modeled were not perfectly understood. Integrating new tools/ technologies to find solution to professional problems in reasonable time was the guru mantra.

## Civil Engineering

### 1. Anti-Seismic Bricks to Improve Buildings' Response to Earthquakes

Sisbrick is a new class of earthquake-resistant building materials that seismically isolates partition walls from the main building structure, significantly reducing the tension between these two elements and, therefore, the damage incurred. Researchers from the Polytechnic University of Valencia (UPV) have designed a new seismic isolator that improves the way buildings respond to earthquakes. The key to the Sisbrick lies in the way different materials have been combined to achieve two main effects: it is able to absorb horizontal seismic movements, while also supporting vertical loads (for instance, partition walls) that act on the integrity of the building frame. Designed specifically for use in partition walls, its brick form means it can be readily incorporated into traditional construction techniques, without the need for additional measures or equipment. Techniques and special bricks to improve the way buildings respond to earthquakes are already available on the market. However, what sets Sisbrick apart is its approach to partition walls. As a researcher at UPV explains, these structures greatly condition a building's response to a seismic event. Merely making partition walls more resistant, does not address the more widespread damage caused by earthquakes. The Sisbrick's large capacity to absorb the horizontal movements caused by earthquakes seismically isolates the partition walls from the main building frame: "They effectively serve as an insulating barrier, avoiding the transfer of loads from these partition elements to the main structure. By doing so, their impact on overall structural integrity in the face of an earthquake is greatly reduced" researchers said. This also brings real seismic response into line with projected seismic response as calculated at the building design stage. Today, seismic calculations only take into consideration the structure of the building frame and do not consider the partition walls, despite the clear and widely-reported influence they have on a building's response to earthquakes. By isolating the partition walls from the main frame, these calculations become more reliable. On top of the convenient brick form, only a relatively small amount of these bricks is needed to achieve this seismic isolation. Laboratory testing proves that, if the bricks are arranged in a specific way, just a small amount can afford significant gains in seismic wave absorption. Specifically, partition walls that incorporate Sisbricks can absorb horizontal movements in the order of three times greater than those that do not. This translates into considerably less tension in the partition walls, meaning correspondingly less tension is transferred to the building frame during earthquakes. The Sisbrick has been patented by the UPV. Testing is currently being carried out into the thermal and acoustic isolation afforded by this material, in order to comply with the specifications of the Building Code.

Source <http://www.sciencedaily.com/releases/2015/11/151125083932.htm>

---

### 2. Encryption Technologies for the Era of Quantum Computers: Effective Protection for Microdevices

Ruhr-Universität Bochum engineers have developed encryption technologies for practical applications to protect microdevices from hacker attacks conducted by quantum computers. The Hardware Security Group at the Ruhr-Universität Bochum is currently working towards protecting the data against threats of tomorrow with the devices available today. Due to a novel computation paradigm, quantum computers could break certain cryptographic techniques that are widely used today. We must now brace ourselves for the fact that highly powerful quantum computers may exist in a few years' time, says Prof Dr.-Ing. Tim Güneysu, who had been researching at the Ruhr-Universität Bochum, under the umbrella of the "Post-Quantum Cryptography" project. Cryptography is implemented in many devices with a long service life, for example in satellites. Those devices have to remain secure in many years' to come. Likewise, microdevices handling long-term critical data, such as electronic health cards, require cryptographic systems that are secure in the long term. Under the project "Post-Quantum Cryptography," Tim Güneysu and his colleagues identified categories of cryptographic techniques which can ensure security even in the era of quantum computers. Moreover, the IT security experts demonstrated that those techniques can also be implemented in microdevices, such as electronic health cards. The challenge associated with techniques of so-called post-quantum cryptography is the fact that they require extremely long cryptographic keys. The low-performance processors of current microdevices cannot yet handle those long keys efficiently. In order to tackle this problem, the researchers used primarily alternative representations of cryptographic techniques, which, for example, introduce additional structures aiming at reducing the key size. Moreover, they also optimized the algorithms for the respective target platform. Depending on the technique they used, the researchers were able to merge complex steps with other computations or even to omit them completely, without reducing the security margin of the cryptographic scheme.

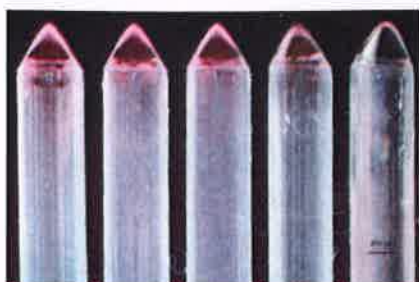
Source <http://www.sciencedaily.com/releases/2015/12/151218085927.htm>

---



## Mechanical Engineering

### 3. Nanodevices at One-hundredth the Cost



*External row of seven emitters that are part of a 49-emitter array. The scalloping on the exterior of the emitters, due to the layer-by-layer manufacturing, is visible.*

Microelectromechanical systems -- or MEMS -- were a \$12 billion business in 2014 in USA. But that market is dominated by just a handful of devices, such as the accelerometers that reorient the screens of most smartphones. That's because manufacturing MEMS has traditionally required sophisticated semiconductor fabrication facilities, which cost tens of millions of dollars to build. Potentially useful MEMS have languished in development because they don't have markets large enough to justify the initial capital investment in production. Two recent papers from researchers at MIT's Microsystems Technologies Laboratories offer hope that that might change. In one, the researchers show that a MEMS-based gas sensor manufactured with a desktop device performs at least as well as commercial sensors built at conventional production facilities. In the other paper, they show that the central component of the desktop fabrication device can itself be built with a 3-D printer. Together, the papers suggest that a widely used type of MEMS gas sensor could be produced at one-hundredth the cost with no loss of quality. The researchers' fabrication device sidesteps many of the requirements that make conventional MEMS manufacture expensive. "The additive manufacturing we're doing is based on low temperature and no vacuum," says Velásquez-García, a principal research scientist in MIT's Microsystems Technology Laboratories and senior author on both papers. "The highest temperature we've used is probably 60 degrees Celsius. In a chip, you probably need to grow oxide, which grows at around 1,000 degrees Celsius. And in many cases the reactors require these high vacuums to prevent contamination. We also make the devices very quickly. The devices we reported are made in a matter of hours from beginning to end." For years, Velásquez-García has been researching manufacturing techniques that involve dense arrays of emitters that eject microscopic streams of fluid when subjected to strong electric fields. For the gas sensors, they used so-called "internally fed emitters." These are emitters with cylindrical bores that allow fluid to pass through them. In this case, the fluid contained tiny flakes of graphene oxide. They used their emitters to spray the fluid in a prescribed pattern on a silicon substrate. The fluid quickly evaporated; leaving a coating of graphene oxide flakes only a few tens of nanometers thick. The flakes are so thin that interaction with gas molecules changes their resistance in a measurable way, making them useful for sensing. "We ran the gas sensors head to head with a commercial product that cost hundreds of dollars," Velásquez-García says. "What we showed is that they are as precise, and they are faster. We make at a very low cost -- probably cents -- something that works as well as or better than the commercial counterparts." To produce those sensors, the researchers used electro spray emitters that had been built using conventional processes. Later they used an affordable, high-quality 3-D printer to produce plastic electro spray emitters whose size and performance match those of the emitters that yielded the gas sensors. In addition to making electro spray devices more cost-effective, Velásquez-García says, 3-D printing also makes it easier to customize them for particular applications. The advantages of electro spray are not so much in enabling existing MEMS devices to be made more cheaply as in enabling wholly new devices. Besides making small-market MEMS products cost-effective, electro spray could enable products incompatible with existing manufacturing techniques. Electro spray could also lead to novel biological sensors. "It allows us to deposit materials that would not be compatible with high-temperature semiconductor manufacturing, like biological molecules," the researcher says.

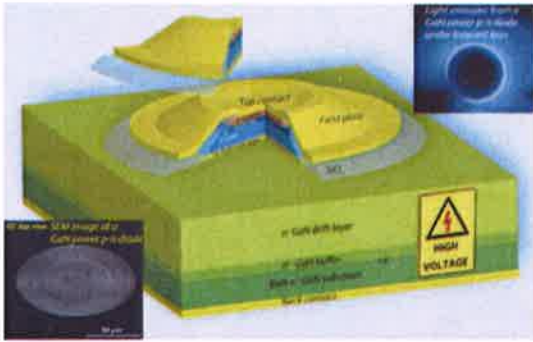
### 4. Detecting, Identifying Explosives with Single Test

A new test for detecting multiple explosives simultaneously has been developed by University College London (UCL) scientists. The proof-of-concept sensor is designed to quickly identify and quantify five commonly used explosives in solution to help track toxic contamination in waste water and improve the safety of public spaces. Lead researcher, Dr William Peveler said: "This is the first time multiple explosives have been detected using a single sensor before, demonstrating proof-of-concept for this approach. Our sensor changes colour within 10 seconds to give information about how much and what explosives are present in a sample. Following further development, we hope it will be used to quickly analyse the nature of threats and inform tailored responses." The study used a fluorescent sensor to detect and differentiate between DNT, TNT, tetryl, RDX and PETN by reading unique colour change 'fingerprints' for each compound. Dr Peveler added: "We analysed explosives which are commonly used for industrial and military purposes to create a useful tool for environmental and security monitoring. For example, DNT is a breakdown product from landmines, and RDX and PETN have been used in terror plots in recent years as they can be hard to detect using sniffer dogs. Our test can quickly identify these compounds so we see it having a variety of applications from monitoring the waste water of munitions factories and military ranges to finding evidence of illicit activities." The sensor is made of quantum dots, which are tiny light-emitting particles or nanomaterials, to which explosive targeting receptors are attached. As each explosive binds to the quantum dot, it quenches the light being emitted to a different degree. The distinct changes in colour are analysed computationally in a variety of conditions to give a unique fingerprint for each compound, allowing multiple explosives to be detected with a single test. Researchers, said: "Our sensor is a significant step forward for multiple explosives detection. Current methods can be laborious and require expensive equipment but our test is designed to be inexpensive, fast and use a much smaller volume of sample than previously possible. Although all of these factors are important, speed and accuracy are crucial when identifying explosive compounds." The team plan to take it from the laboratory into the field by blind testing it with contaminated waste water samples. They also hope to improve the sensitivity of the test by tailoring the surfaces of the quantum dots. Currently, its limit is less than one part per million which the team hope to increase into the part per billion range.

Source <http://www.sciencedaily.com/releases/2015/12/151209091353.htm>

---

### 5. Building Blocks for GaN Power Switches



*This image shows a state-of-the-art design of GaN p-n junction diodes that has resulted in near-unity ideality factor, avalanche breakdown capability, and record-breaking power performance. Insets show a GaN p-n diode fabricated on a high-quality bulk GaN substrate and light emission from the junction under forward bias.*

A team of engineers from Cornell University, the University of Notre Dame and the semiconductor company IQE has created gallium nitride (GaN) power diodes capable of serving as the building blocks for future GaN power switches -- with applications spanning nearly all electronics products and electricity distribution infrastructures. Power semiconductor devices are a critical part of the energy infrastructure -- all electronics rely on them to control or convert electrical energy. Silicon-based semiconductors are rapidly approaching their performance limits within electronics, so materials such as GaN are being explored as potential replacements that may render silicon switches obsolete. But along with having many desirable features as a material, GaN is notorious for its defects and reliability issues. So the team zeroed in on devices based on GaN with record-low defect concentrations to probe GaN's ultimate performance limits for power electronics. "Our engineering goal is to develop inexpensive, reliable, high-efficiency switches to condition electricity -- from where it's generated to where it's consumed within electric power systems -- to replace generations-old, bulky, and inefficient technologies," said a researcher at Cornell University. "GaN-based power devices are enabling technologies to achieve this goal." The team examined semiconductor p-n junctions, made by joining p-type (free holes) and n-type (free electrons) semiconductor materials, which have direct applications in solar cells, light-emitting diodes (LEDs), rectifiers in circuits, and numerous variations in more complex devices such as power transistors. "For our work, high-voltage p-n junction diodes are used to probe the material properties of GaN," researchers explained. To describe how much the device's current-voltage characteristics deviate from the ideal case in a defect-free semiconductor system, the team uses a "diode ideality factor." This is "an extremely sensitive indicator of the bulk defects, interface and surface defects, and resistance of the device," the researcher added. Defects exist within all materials, but at varying levels. "So one parameter we used to effectively describe the defect level in a material is the Shockley-Read-Hall (SRH) recombination lifetime," researchers said. SRH lifetime is the averaged time it takes injected electrons and holes in the junction to move around before recombining at defects. The lower the defect level, the longer the SRH lifetime. For GaN, a longer SRH lifetime results in a brighter light emission produced by the diode. The work is significant because many researchers around the globe are working to find ways to make GaN materials reliable for use within future electronics. Due to the presence of defects with high concentrations in typical GaN materials today, GaN-based devices often operate at a fraction of what GaN is truly capable of. Though operating at compromised conditions, GaN LEDs are helping to shift the global lighting industry to a much more energy-efficient, solid-state lighting era. The work at Cornell University is the first report of GaN p-n diodes with near-ideal performance in all aspects simultaneously: a unity ideality factor, avalanche breakdown voltage, and about a two-fold improvement in device figure-of-merits over previous records.

## Electronics and Communication Engineering

### 6. Atomically Flat Tunnel Transistor Overcomes Fundamental Power Challenge of Electronics



*Professor Kaustav Banerjee (right) with researchers in his Nanoelectronics Research Lab at UC Santa Barbara.*

One of the greatest challenges in the evolution of electronics has been to reduce power consumption during transistor switching operation. In a study recently engineers at University of California, Santa Barbara have demonstrated a new transistor that switches at only 0.1 volts and reduces power dissipation by over 90% compared to state-of-the-art silicon transistors (MOSFETs). MOSFETs have been the building blocks of everyday electronic products since the 1970s. However, to sustain the ever-growing need for increased transistor densities, miniaturization of MOSFETs has given rise to a power dissipation challenge due to the fundamental limitations of their turn-on characteristics. "The steepness of a transistor's turn-on is characterized by a parameter known as the sub-threshold swing, which cannot be lowered below a certain level in MOSFETs," explained Kaustav Banerjee, Professor of Electrical and Computer Engineering at UC Santa Barbara. A minimum gate voltage change of 60 millivolts at room temperature is required to change the current by a factor of ten in MOSFETs. In essence, the existing state of transistor technology limits the energy efficiency potential of digital circuits in general. The research group of Professor Kaustav Banerjee took a new approach to subverting this fundamental limitation. They employed the quantum mechanical phenomenon of band-to-band tunneling to design a tunnel field effect transistor (TFET) with sub-60mV per decade of sub-threshold swing. "We restructured the transistor's source to channel junction to filter out high energy electrons that can diffuse over the source/channel barrier even in the off state, thereby making the off state current negligibly small," explained Banerjee. Banerjee and his colleagues are motivated by a global electronics industry that loses billions of dollars each year to the impact of power dissipation on chip cost and reliability. "This translates into lower battery lifetime in personal devices like cell phones and laptops, and massive power consumption of servers in large data centers," adds Banerjee, pointing out the global scale of this energy demand. An industry that relies on conventional semiconductors such as silicon or III-V compound semiconductors as the channel material for TFETs, Banerjee explains, "faces limitations because these materials have high density of surface states, which increase leakage current and degrade the sub-threshold swing." The TFET designed by the UCSB team overcame this challenge in a few ways, most significant being the use of a layered two-dimensional (2D) material called molybdenum disulphide (MoS<sub>2</sub>). As the current-carrying channel placed over a highly doped germanium (Ge) as the source electrode, MoS<sub>2</sub> offers an ideal surface and thickness of only 1.3nm. The resulting vertical heterostructure provides a unique source-channel junction that is strain-free, has a low barrier for current-carrying electrons to tunnel through from Ge to MoS<sub>2</sub> through an ultra-thin (~0.34nm) van der Waals gap, and a large tunneling area. "The crux of our idea is to combine 3D and 2D materials in a unique heterostructure, to achieve the best of both worlds. The matured doping technology of 3D structures is joined to the ultra-thin nature and pristine interfaces of 2D layers to obtain an efficient quantum-mechanical tunneling barrier, which can be easily tuned by the gate," said researchers. "We have engineered what is, at present, the thinnest-channel subthermionic transistor ever made," said Banerjee. Their atomically-thin and layered semiconducting channel tunnel FET (or ATLAS-TFET) is the only planar architecture TFET to achieve sub-thermionic sub-threshold swing (~30 millivolts/decade at room temperature) over four decades of drain current, and the only one in any architecture to achieve so at an ultra-low drain-source voltage of 0.1V. The transistor can be utilized for a number of low-power applications including arenas where the steep sub-threshold swing is the main requirement, such as biosensors or gas sensors.

### 7. ISRO Successfully Tests Multiple Burn PSLV Engine

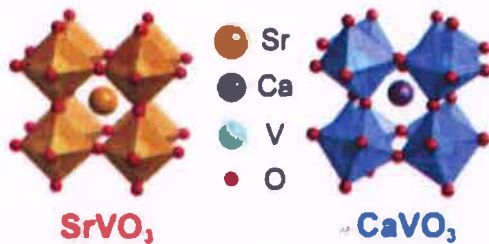


Indian Space Research Organization on Dec 16, 2015 successfully tested restarting of its Polar Satellite Launch Vehicle (PSLV) rocket after its engine was cut off during the mission to launch six Singaporean satellites. "The restart test was successful. The engine was fired for nearly five seconds. We will be using this technology sometime next year," Indian Space Research Organisation chairman A.S. Kiran Kumar said. He said that next three satellite launches using PSLV rocket will be navigation satellites. After that, there will be some multiple satellite launches and this technology will be used, he added. "The restart of the engine happened beautifully. The test was a success," S. Somnath, director of the Liquid Propulsions Systems Centre, told IANS. According to him, the multiple burn fuel stage/engine will be used in PSLV-C35 rocket which will carry two satellites. One satellite will be launched at a higher orbit and the other one will be at a slightly lower orbit, he said. "The restart and shut off of the fourth stage engine is done as a first step towards launching multiple satellites but in different orbits," said an ISRO official. Launching of multiple satellites with a single rocket is nothing new for ISRO and it has been doing that for several years. The challenge, however, is to launch several satellites at different orbits with one rocket. This is what ISRO tested after PSLV ejected out six Singaporean satellites. The PSLV rocket is a four stage/engine rocket powered by solid and liquid fuel alternatively. "Restarting a rocket engine soon after it is shut off is a critical technology that has to be mastered. Once a rocket engine is activated, then the heat generated is very high. The trick is to cool it down in the space and to restart it at a short gap," an industry expert told IANS. "This is entirely different from switching on and off the communication satellite's engines in the space. The interval between two restarts of a communication satellite engine will be in days. But in the case of restarting a rocket engine, the time gap will be in hours," the expert added. "By that time the rocket's engine has to be cooled down. This part of the experiment is very critical," he explained. The PSLV's fourth stage was restarted successfully at just over 67 minutes into the flight or 50 minutes after the engine was cut off. At the time of restart the fourth stage was in a lower altitude of 523.9 km while the satellites were ejected at 550 km altitude. The engine operating for few seconds went up to an altitude of 524 km before the stage was cut off again.

Source <http://gadgets.ndtv.com/science/news/isro-successfully-tests-multiple-burn-pslv-engine-on-wednesday-779156>

---

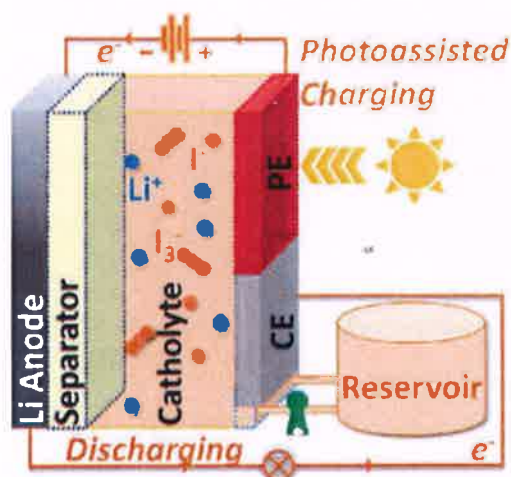
### 8. Transparent Metal Films for Smart Phone, Tablet and TV Displays



*A figure showing the crystal structure of strontium vanadate (orange) and calcium vanadate (blue). The red dots are oxygen atoms arranged in 8 octahedra surrounding a single strontium or calcium atom. Vanadium atoms can be seen inside each octahedron.*

A new material that is both highly transparent and electrically conductive could make large screen displays, smart windows and even touch screens and solar cells more affordable and efficient, according to materials scientists and engineers at Penn State who have discovered just such a material. Indium tin oxide (ITO), the transparent conductor that is now used for more than 90 percent of the display market, has been the dominant material for the past 60 years. But in the last decade, the price of indium has increased dramatically. Displays and touchscreen modules have become a main cost driver in mobile devices, such as smartphones and tablets, making up close to 40 percent of the cost. While memory chips and processors get cheaper, following Moore's Law, smartphone and tablet displays get more expensive from generation to generation. Manufacturers have searched for a possible ITO replacement, but until now, nothing has matched ITO's combination of optical transparency, electrical conductivity and ease of fabrication. Roman Engel-Herbert, assistant professor of materials science and engineering, and his team report a new design strategy that approaches the problem from a different angle. The researchers use thin (10 nanometer) films of an unusual class of materials -- called correlated metals -- in which the electrons flow like a liquid. While in most conventional metals, such as copper, gold, aluminum or silver, electrons flow like a gas, in correlated metals, such as strontium vanadate and calcium vanadate, they move like a liquid. The authors in a paper explain why these correlated metals show a high optical transparency despite their high, metal-like conductivity. "We are trying to make metals transparent by changing the effective mass of their electrons," Engel-Herbert says. "We are doing this by choosing materials in which the electrostatic interaction between negatively charged electrons is very large compared to their kinetic energy. As a result of this strong electron correlation effect, electrons 'feel' each other and behave like a liquid rather than a gas of non-interacting particles. This electron liquid is still highly conductive, but when you shine light on it, it becomes less reflective, thus much more transparent." To better understand how they achieved this fine balance between transparency and conductivity, they turned to a materials theory expert in Rutgers University. They needed help to put a number on how 'liquid' this electron liquid in strontium vanadate is. The researcher helped the Penn State team put together all the theoretical and mathematical puzzle pieces they needed to build transparent conductors in the form of a correlated metal. Now that they understand the essential mechanism behind their discovery, the Penn State researchers are confident they will find many other correlated metals that behave like strontium vanadate and calcium vanadate. "Our correlated metals work really well compared to ITO. Now, the question is how to implement these new materials into a large scale manufacturing process. From what we understand right now, there is no reason that strontium vanadate could not replace ITO in the same equipment currently used in industry," says Engel-Herbert. Along with display technologies, Engel-Herbert and his group are excited about combining their new materials with a very promising type of solar cell that uses a class of materials called organic perovskites. Developed only within the last half dozen years, these materials outperform commercial silicon solar cells but require an inexpensive transparent conductor. Strontium vanadate, also a perovskite, has a compatible structure that makes this an interesting possibility for future inexpensive, high-efficiency solar cells.

9. Eco-Friendly Battery and Solar Cell All-In-One



*Schematic of a "solar flow battery" with the three-electrode configuration: lithium anode electrode, counter electrode (CE), and photo-electrode (PE). Current passes through a liquid in the battery called an electrolyte. The portion of the electrolyte near the cathode electrode is called a "catholyte." The CE and PE electrodes are in contact with the "catholyte."*

More efficient, eco-friendly electricity generation with a "solar flow battery" combines a redox flow battery and a dye-sensitized solar cell, using compatible, water-based (aqueous) solvents. Solar energy is harvested and stored as chemical energy during the charging process. When it is time to recharge the battery, the amount of energy needed to is lower than conventional lithium-iodine batteries because dye molecules, exposed to the sun, donate electrons to the recharging process. Energy generation from a solar flow battery is more cost-effective, eco-friendly, and can achieve energy savings up to 20% compared to conventional lithium-iodine batteries. Solar flow batteries make renewable solar energy more practical for keeping the lights on and appliances running with stand-alone electricity generation and storage. Last year, researchers at The Ohio State University demonstrated photo-assisted charging of a lithium-oxygen (Li-O<sub>2</sub>) battery; however, they used organic (carbon-based) solvents that limited its compatibility with aqueous redox flow batteries. Now, these researchers have built a solar flow battery that uses an eco-friendly, compatible solvent and requires a lower applied voltage to recharge the battery. In solar flow batteries, the proposed charging process links harvesting solar energy and storing it as chemical energy via the electrolyte. The aqueous electrolyte is in contact with the counter electrode of the battery and the dye-sensitized photo-electrode of the solar cell. To recharge the battery, it is exposed to sunlight. The sunlight causes the dye molecules in the electrolyte to donate electrons to the photo-electrode, reducing the amount of energy needed to recharge the battery. The applied voltage to recharge the solar flow battery is reduced to 2.9 Volts compared to over 3.6 Volts for conventional lithium-iodine batteries, resulting in an energy savings of up to 20%. The aqueous solar flow battery performs better and is more cost-effective and eco-friendly than those based on organic solvents. The aqueous solar flow battery could solve the intermittency shortcomings of renewable energy and keep the lights on and appliances running.

Source <http://www.sciencedaily.com/releases/2015/12/151208150948.htm>

## Interdisciplinary Engineering and Special Fields

### 10. Telepresence Robot for the Disabled Takes Directions from Brain Signals



*Brain control becomes a more practical way to control robots when the machines can do some things for themselves.*

People with severe motor disabilities are testing a new way to interact with the world—using a robot controlled by brain signals. An experimental telepresence robot created by Italian and Swiss researchers uses its own intelligence to make things easier for the person using it, through a system dubbed shared control. The user tells the robot where to go via a brainwave-detecting headset, and the robot takes care of details like avoiding obstacles and determining the best route forward. The robot is essentially a laptop mounted on a rolling base—the user sees the robot’s surroundings via the laptop’s webcam, and can converse with people over Skype. To move the robot, users wear a skullcap studded with electroencephalogram (EEG) sensors, and imagine movements with their feet or hands. Each movement corresponds with a different command, such as forward, backward, left, or right. Software translates the different signals generated into actions for the robot. However, the robot’s control software decides for itself the best way to change trajectories and accelerate to get where it has been told to go. It has nine infrared sensors that alert it to obstacles, which it can move around while also following the user’s directions. That design makes the robot easy enough to use that it could offer a practical way to give disabled people more independence, says Robert Leeb, a research scientist at the Swiss Federal Institute of Technology in Lausanne who worked on the project. “Imagine an end-user lying in his bed at home connected to all the necessary equipment to support his life,” he says. “With such a telepresence robot, he could again participate in his family life.” The researchers tested the robot by having people with and without motor disabilities navigate it through several rooms filled with obstacles. Both groups were able to steer through the course in similar times. They needed to use fewer commands than when they controlled the robot entirely, and completed the course faster. Participants without motor disabilities were also tested on how quickly they could manually navigate the robot without giving it any autonomy. The study found their times to be only slightly shorter than when they shared control and navigated via brain-computer interface. Researchers are exploring using brain-computer interfaces for everything from steering wheelchairs to moving prosthetic limbs. Versions that are implanted into the brain can give people impressive control of robotic limbs, but are challenging to install and maintain, and not widely used. Non-invasive brain-computer interfaces that listen for EEG signals simply by touching the scalp at several points are less powerful but more practical. Simple systems are available for home use, such as the Muse headband, intended to aid meditation, and Emotiv, designed for gaming. Most effort on commercializing EEG-based brain-computer interfaces is focused on low-cost single-purpose devices, not making high-quality sensors that could be used in many different applications. “If we develop a system which can then be used easily by everybody, just like a cell phone, this would push the brain-computer interface technology wide out,” researchers say.

Source <http://www.technologyreview.com/news/543936/telepresence-robot-for-the-disabled-takes-directions-from-brain-signals/>

---



## **Engineering Innovation in India**

### **Redpine Signals**

Redpine Signals, Hyderabad was founded in 2001 by industry veterans with a vision to build a company with a culture of innovation. The company provides an end-to-end solution for chipsets, modules, devices, cloud and application development. Redpine's main thread and differentiation has been their endeavour to "Expand the Wireless Horizons". The company's worldwide sales cover North America, South America, Europe, Middle East & Africa, Asia-Pacific and Australia and New Zealand. Ms Kalpana Atluri, Founder and President, Redpine Signals holds a Masters Degree in Electrical Engineering from Jawaharlal Nehru Technological University, Hyderabad and has over 24 years of experience in the semiconductor industry. Mr Narasimhan Venkatesh, FNAE, Senior Vice President, Advanced Technologies has over 28 years of engineering and management experience in wireless system design, telecommunications, optical networking and avionics. Mr. Venkatesh is a key wireless technologist and champions the universal integration of wireless into embedded systems. He holds a Masters Degree in Electrical Engineering from the Indian Institute of Technology, Madras.

Redpine has spent more than 1000 man years in research and innovation into next-generation Wireless technologies based on Orthogonal frequency-division multiplexing (OFDM) and multiple-input and multiple-output, (MIMO), resulting in over 100 patents, patent filings and disclosures. Redpine's solutions have industry leading performance, cost and power-consumption – all in a single product. The company has focused on innovation through research in areas that include OFDM/OFDMA, MIMO, energy efficient wireless, wireless operation in dense environments, low power Complementary metal-oxide-semiconductor (CMOS) RF and high efficiency CMOS PAs.

India Electronics and Semiconductor Association (IESA), the premier body representing the electronics system design and manufacturing (ESDM) eco-system in India, awarded the Technovation 2013 Award for Most Innovative Product to four organizations including Redpine Signals. These awards honour stalwarts in the industry and academia who have furthered the growth and development of electronics and semiconductor industry in the country.

Redpine Signals also received the 2015 New Product Innovation Award in recognition of its unique and comprehensive WyzBee platform that has the potential to alter next-generation IoT applications and devices as a single-source solution. Redpine's engineering technologies and solutions that are marked by innovation, high-precision performance, security, ease of use and application diversity has strengthened its brand equity. Its chipsets have demonstrated high-performance capabilities over the years and have been incorporated in many leading devices. In a highly competitive market, WyzBee differentiates itself by catering to the specific needs of a wide range of customers. A large number of small and medium device developers with specific and small-scale needs can opt for the WyzBee platform. Its wide-ranging services reduce not only the cost of device development and deployment, but also the time to market for manufacturers in the IoT industry.

Source <http://www.redpinesignals.com/>

---