



ENERGIZER

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Department of Energy Science and Engineering, IIT Bombay

02 | Spotlight: ICAER 2019

Highlights from our flagship conference

07 | Hydrogen and Hydrocarbons

New strides in energy systems research

India's 100 GW Solar PV Mission and the Challenges Beyond | 04

Insights from Prof S. P. Sukhatme, former Director, IIT Bombay

...and news, interviews, and more!

Straight from the HoD

I am delighted to see the launch of our department newsletter *ENsider*. We have come a long way since 1981 when we started as a small interdisciplinary programme hosted by the Department of Mechanical Engineering. In 2007, we grew into a full-fledged Department of Energy Science and Engineering, one of the first such academic entities in the country. We are now a community of around 500 students, staff, project staff, and faculty members. We have completed the shift to our new department building which has given us a greater sense of identity and pride.

We felt that this was the right time to have a newsletter managed by the students reporting on happenings, news and views. In view of the lockdown, we decided to go for an e-release. We look forward to your comments, suggestions and contributions for the newsletter. This is **your** medium and I hope that you will respond enthusiastically so that we can have regular issues that are interesting.

We look forward to the post-lockdown times where we can resume the functioning of teaching and research in the department. It is likely that there will be a new normal for quite some time where we follow a different set of interaction and operation norms to keep away the COVID infection. The last month has shown us that transitions and change is the order of the day. This provides a challenge as well an opportunity for all of us to reimagine the way in which society and energy systems can be designed and operated.

Wishing you and your family good health in these troubled times.

Rangan Banerjee

Editor's Corner

Four months back when the idea of a department newsletter was mooted, it was an idea whose time had finally come. Since being set up in 2007, DESE has made significant contributions to the energy sector, in academia as well as industry. As the world moves forward to address climate change, our relevance is only set to grow. *ENsider* aims to give you a glimpse of the activities at DESE and the people behind them, and promote discussion on issues of energy and sustainability.

We appreciate Prof Sandeep Kumar and Sisir Yalamanchili who took time out from their busy schedules for the interviews. We are grateful to Prof Anish Modi and Prof Zakir Hussain for their constructive inputs. We would also like to thank Aayush Garg, DESE General Secretary, for his support. We welcome your feedback on this issue and ideas for the next. You can e-mail us at energynews@ese.iitb.ac.in.

Stay safe and happy reading!

Kumaresh Ramesh

Energy Buzz

Central government opens a Renewable Energy Facilitation Centre

What will it do?

The Industry and Investors' Facilitation Centre has been opened to provide information on government-led initiatives and resolve issues faced by investors and industry.

Why is it important?

While the Centre has an ambitious plan of 175 GW installed RE capacity by 2022, players in the industry often receive conflicting signals from different state-run organizations. A single window to address these concerns will go a long way in reducing uncertainty and promoting investment.

Solar-powered education in rural Maharashtra

What has been decided?

To counter the effects of frequent power-cuts, solar panels will be installed in government schools in rural Maharashtra. No concrete proposal, however, has been finalized for the same.

How will this help?

Solar generation will not just ensure a more reliable supply, but also ease the stress on the exchequer that is facing mounting pressure from the school's unpaid dues. This move will also help to truly realize the benefits of the digitization drive undertaken by the state government.

Prices for renewable-cum-storage fall to ₹ 4.04/kWh

When did this happen?

SECI's reverse auction for what is touted as the world's largest renewable-cum-energy storage tender concluded in January. Greenko placed the lowest bid at Rs 4.04/kWh for 900 MW, while the remainder 300 MW was secured by ReNew Power who bid at Rs 4.30/kWh.

What does this mean for the power industry?

While the peak prices for both bids are above Rs 6/kWh, the falling trend in the prices firmly indicate that storage can aid the penetration of renewables in our grid. Further, the fact that these tariffs have been fixed for 25 years indicate the bidders' confidence in the feasibility of these technologies. Within the renewables sector, however, this may further tilt the market towards largescale installations as opposed to decentralized production.

Surplus-powered green hydrogen to be commercialized

Who have undertaken the project?

Three Belgian companies, offshore engineers DEME, financier PMV and the Port of Ostend, have come together to build by 2025 the world's first commercial-scale hydrogen plant to be powered solely by surplus offshore wind energy.

Why is this a huge deal?

Whenever there is surplus power production, renewable sources are curtailed to ensure supply-balance. However, this project can pave way for surplus renewable energy to be utilized towards production of hydrogen, which can be used for transport and heating, among other uses.

Spotlight: ICAER 2019

DESE organized the 7th International Conference on Advances in Energy Research (ICAER 2019) between 10 and 12 December 2019. Sponsored by ONGC and Coal India, among others, the conference saw active participation from academia and industry. Several steps were taken to promote sustainability. These included using cloth-based registration kits, notebooks made from recycled paper, and minimizing use of single-use plastic.

ICAER 2019 IN NUMBERS

100+ **200+** **450+**

Industry delegates Presentations Attendees



Volunteer Speak

Soham Phanse, 1st year UG

When I first came to IITB, I didn't know much about my department. I had just roughly seen my course curriculum and, so, wanted to know more about the research going on. Thus, I took the opportunity to volunteer for ICAER. Almost every single aspect was new for me: core talks, journals,

Two special sessions were organized: (a) Future of coal research and (b) Industry innovations in energy. The second session saw experts from various organizations like Aditya Birla Group, Siemens (Gas & Power), Tata Power, Thermax and Vedanta present exciting developments. The conference concluded with a panel discussion on energy transition and energy security. On the panel were Karthik Ganesan, Research Fellow at CEEW, Dr Anuradda Ganesh, Director (Research and Innovation) at Cummins, Sören Huittinen, Head of Products R&D, India for Siemens, and Dr Keith Lovegrove, MD, ITP Thermal Pvt Ltd.

posters; but I was happy to see students from various backgrounds come to showcase their research. Although I didn't understand much of the advanced talks, I got to know about our international reach in various areas of research. It was good to see that our department, although young, just like the energy engineering sector has its roots spread deep within. I also got to interact with some of our students and professors who put in tremendous effort to organize the event. The conference was an enriching experience as it gave me a good idea of my academic future.

The Prof-ile View



Prof Sandeep Kumar has completed his Bachelors in Mechanical Engineering from NIT Silchar and PhD from IISc. His primary research interests lie in the fields of combustion and biofuels. He joined the department as an Assistant Professor in August 2017.

Tell us about your journey before coming to IIT Bombay.

In the vacation after my Class 10 exams, I tried reading commerce textbooks, but found them boring. And then, as my school offered only Science stream, I decided to try it. I took up mechanical engineering, only to end up as a software professional in Infosys. Although it was a high-paying job and life in Bengaluru was enjoyable at first, it was never truly fulfilling. I was growing tired of it when a chance to pursue higher education in IISc cropped up. I completed my post-graduation and PhD from the college and haven't looked back since.

What are three things that you liked about IIT Bombay?

The college campus is quite good. Apart from its size, the facilities on offer and the green cover are very impressive. The various programs hosted by students give the campus a vibrant culture throughout the year. A lot of people here are health-conscious and can be found jogging or cycling. Thus, I do not feel out of place when I use my bicycle to commute within the institute.

What is one thing where the institute could improve upon its current standards?

With so many people studying and working here, the institute should put greater focus on improving the accommodation facilities here. This is a problem faced by all residents and must be rectified as soon as possible.

How has student life changed between your time and now?

Earlier, the process was centred around the classroom. As a student, I was dependent on class notes and textbooks. Internet came to my college only in the third year, and by then, it was too late. Digital learning has opened up our access to new resources. In addition, it has helped to foster better interaction between teachers and students. On the other hand, I feel that technology has decreased the level of discipline in today's students. Also, we used to get together and enjoy our time together, be it by watching movies, playing sports or just plain gossip. Today, however, students just sit in their rooms and do not socialize a lot.

What do you enjoy apart from teaching and research?

I like to remain fit by jogging and cycling. Although, I love reading books, I haven't been able to do so in the recent weeks due to lack of time.

If not a professor, what would you have become?

Still remained a software engineer at Infosys!

What would be your advice to current students?

We go with the flow, often diverging from our individual interests. Do not succumb to peer pressure or what society expects of you. If you want to go non-conventional, you should go ahead with it. Being in IIT, you can always choose a different career path and be equally successful, if not more.

What would you like to tell the students of the department?

As Energy Science and Engineering is an interdisciplinary department, it gives you scope for wider research fields. Hence, utilize this opportunity to its fullest extent. In our department, you connect better to the market forces and societal needs, which should be integral to any research. This human touch sets DESE apart from other departments of the institute.

The 100 GW Solar PV Mission

Introduction

The Government of India has set a target that the nation should have an installed capacity of 100 GW of solar electric power by 2022. Achieving this mission will reduce our dependence on non-renewable sources of energy (coal, oil and natural gas) and contribute to a reduction in global warming. Although 'solar electric power' includes generation of electricity by using both, solar PV cells and the thermal route, in today's context, it essentially means only via PV cells. It is planned that the break-up of the 100 GW capacity would be 60 GW produced in solar PV parks connected to the national grid, and 40 GW in roof-top, decentralized systems. The target set is clearly very ambitious when one considers the fact that in 2010, the installed capacity of solar PV in the whole country was not even 1 GW.

Present Scenarios and Expectations from the 100 GW Mission

A comparison of the present scenario (2019) and the situation expected in 2022 if the mission is fully accomplished is given in the following table.

	2019	2022
Installed capacity in India (GW)	361	522 ⁺
Solar PV capacity in India (GW)	28.5 ⁺⁺	100
% of total	7.9	19.2
Total electrical energy produced annually (TWh)	1547	2241
Mean annual per capita availability (kWh)	1181	1550
Electrical energy from solar PV (TWh)	39.3	157
% of total	2.5	7
⁺ Assuming a growth of 11.2% annually		
⁺⁺ Break-up: Solar parks 26.6 GW: roof tops 1.9 GW		

The data shows that if the goals of the mission are achieved, solar PV will start making a noticeable impact on the overall electrical energy scene. It could be providing as much as 7% of the electrical energy produced in 2022. With reasonable funding and business models, a guess today is that the target of 60 GW for solar parks will be achieved to a large

extent by 2022. However, for roof-top and decentralized systems, it is unlikely that even 10% of the target of 40 GW will be achieved. Thus, India would have an installed PV capacity between 60 and 70 GW in 2022 and the goals of the 100 GW Mission will probably be achieved to a reasonable extent.

Even before its completion, the 100 GW PV Mission has brought out clearly that photovoltaic conversion is going to be one of the major contributors to the renewable energy scene in the future. It is therefore necessary to ask the following questions:

- What are India's future needs for electricity as it proceeds to become a developed country?
- To what extent can photovoltaic conversion meet the future needs and what are the major challenges if this is to happen?

India's Future Needs of Electricity

It is generally accepted nowadays that a developed country should have a Human Development Index of 0.9 or more. It is also known that in order to achieve this, the mean annual per capita availability of electricity should be at least 4000 kWh. At the present rate of economic development in India, this may take 20 to 30 years. Present population trends in India also show that the population is likely to stabilize to a value of about 1700 million in the next 40 to 50 years. Multiplying the mean annual per capita availability of electricity by the population, we obtain the total future need for electricity. Thus if we assume the per capita need to be satisfied with a value of 4000 kWh, we obtain the future need to be $4000 \times 1700 \times 10^6 \text{ kWh} = 6800 \text{ TWh}$ [1].

To What Extent Can Photovoltaic Conversion Meet Future Needs of Electricity?

Large tracts of land will be needed for generating electricity on a large scale through the PV route. This land has to be barren and uncultivated. We assume that 20% of this land (4 million hectares) can be eventually utilized. Further, using the thumb rule that 2 hectares of land are needed for generating 1 MW, we estimate that 2000 GW can be generated in solar parks in this manner.

and the Challenges Beyond

Typically the annual plant load factor for a solar PV plant is about 0.18. Using this value, the energy generated annually = $2000 \times 8760 \times 0.18 \times 10^{-3} = 3154$ TWh. This is a very significant amount. As far as roof-top PV systems are concerned it is estimated that if 20 million house hold are covered and that the average amount generated per roof- top is 4.5 MWh/year, we would generate 90 TWh annually, a small amount compared to the estimated output of solar parks. Nonetheless, it is a useful contribution.

Adding the two estimates, the energy available from PV comes to $(3154+90) = 3244$ TWh. This is $(3244/6800) \times 100 = 47.7\%$ of the need. We conclude that in the long run, solar PV could be a significant contributor on the national scene.

The Challenges Ahead

Apart from the large investments involved, there are numerous challenges which need to be addressed. These can be broadly classified as (1) technical issues, (2) social issues, and (3) policy issues. We will discuss these in brief.

Technical Issues

Solar energy is an intermittent source with a fluctuating output. However, the demand for electricity is more continuous and round the clock. In order to meet this demand, we will need to develop devices and techniques to store large amounts of energy when supply exceeds demand and to use this stored energy when demand exceeds the supply. In addition, we would need 'smart' power grids to replace present power grids. These smart grids would be able to utilize information and communication technology to gather and act on information about the behaviour of the supply and demand sides in an automated fashion. Such smart grids would need to be developed and designed for Indian conditions.

Social Issues

As we strive to produce more electricity in the future, we must also strive to see that the distribution of electricity amongst the people is more equitable. Today the distribution is not at all equitable. It is highly skewed. Studies show that two-thirds of the population in India

has access to a per capita value which is less than the mean [2]. This is clearly unacceptable.

Policy Issues

Although the growth of solar PV installations in India in the last few years has been very good, it is important to note that most of silicon solar cells / modules used in India today are imported. There is no capacity of making pure silicon or silicon wafers. In fact, there is limited research capability for making solar cells and transferring know-how. If solar PV is to contribute in a big way in the future, India needs to develop its own know-how from start to finish.

In such a quest, the Government has to play a key role because of the investments involved. We need to put together a consortium of research institutes, public and private industry players and ask them to work in a mission mode so as to develop finished products within a reasonable time frame. In the case of solar PV, the goal has to be 'Make in India' to the maximum extent possible. This is the only way to build an 'energy secure' nation.

References

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Professor S. P. Sukhatme is known for his contributions, in teaching and research, in the areas of Heat Transfer and Energy. He played a key role in setting up the IDP in Energy Systems Engineering in 1981 and served as the Director of IIT Bombay from Jan. 1995 to Jan. 2000. He was awarded the Shanti Swarup Bhatnagar Prize in 1983 and the Padma Shri in 2001.

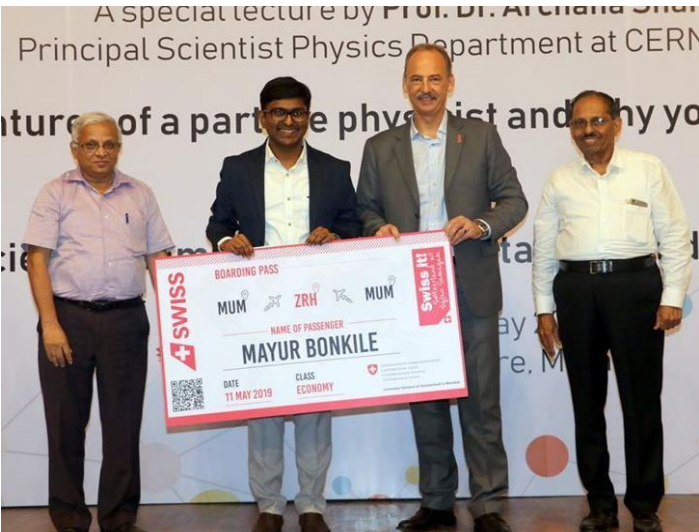
Caught on Camera



Prof Chetan Solanki demonstrates solar cooking



A team of professors and the former Director inspect a space in the new department building and (below) inaugurate the DESE Office.



Mayur, a PhD student, wins Swiss Science Slam 2019



Professor Emeritus J. K. Nayak being honoured by the Director for his contributions to IIT



The future is female – and sustainable!

Hydrogen and Hydrocarbons

*Research in the energy sector should be rooted in socio-economic realities. With this in mind, DESE has entered into two collaborations – one that seeks to reform the energy of the past, and another that aims to realize the energy of the future. **Purushottam Kumar** profiles these initiatives.*

The Centre of Excellence in Oil, Gas and Energy is an interdisciplinary centre of excellence between Indian PSUs (IOCL, ONGC, HPCL, BPCL, GAIL, OIL and EIL) and IIT Bombay. It has been founded to provide a competitive advantage to India's energy sector and its PSUs in the emerging business ecosystem driven by climate challenges, stressed resources and disrupting technologies globally. Several verticals have been targeted to achieve by them. They are making continuous efforts on production of gas from the natural gas hydrate reserves of India discovered by NGHP, integrated reservoir characterization of India's carbonate and tight oil reserves, water management and wastewater management in the upstream and downstream oil and gas industries, digitization for achieving operational excellence and asset-wide optimization.



The CoE-OGE is aiming to facilitate interaction between the oil and gas PSUs and IIT Bombay by organizing focussed meetings, workshops, lecture series, visits and exchange programmes. The research projects from the centre will be based on the pathways for technology development from lab to field. It will also focus on capacity building through CEP courses for PSUs' manpower and internship opportunities for students.

The DST - IITB Energy Storage Platform on Hydrogen is a multi-institutional R&D centre on Hydrogen Energy systems. It aims to engineer and innovate the hydrogen energy technology by sailing on a plethora of dimensions. The centre has broadly classified its aims into four categories: Materials, Devices & Systems, Utilisation and Outreach. Technologies like metal hydrides and other novel materials with a scope of bringing change in the field are being explored for large scale synthesis. The prototypes of ideated designs are simulated and evaluated to gauge their feasibility and safety accurately. Their efforts are motivated to transfer the hydrogen technology for stationary and vehicular demand to the industry in the soonest and safest way possible.



Prof. Andreas Zuttel of EPFL with members of ESPHy on the occasion of International Workshop on Hydrogen Storage

The centre will outreach with the industries and researchers through multiple workshops and conferences to showcase their results. In addition, it will provide mentorship and collaboration that can enhance their efforts. The initiative has gained support from diversified esteemed academic and industrial institutions like the University of Glasgow, Thermax, and NTPC to contribute to making a sustainable future.

The centre will act as a focal point towards development of next generation of materials and technologies, industrial and collaborative interactions, capacity building, knowledge dissemination and deployment of hydrogen based technologies.

Prof. Pratibha Sharma

Down Memory Lane

After toiling for two years, you have just cleared JEE. Now, you must choose your IIT and branch – a decision that will shape not just the next four or five, but, potentially, forty years of your life.

*In 2008, twenty such youngsters chose to place their bets on Energy Science and Engineering, a major that was being offered for the first time at an IIT. **Kumaresh Ramesh** sat down (virtually) with **Sisir Yalamanchili**, a member of this G20 to find out more about his journey before, in, and after IIT.*

Getting here

Much like our beloved department, Sisir has come a long way too. He was enrolled in a Telugu-medium school till Class 5 and came to know about IITs only in Class 10. However, he scored well in his Math and Science boards and we all know how that plays out. On asking him why he didn't go for medicine, he quips, "I was good at maths. Both my parents are doctors, and, frankly, I didn't want to not get sleep at night."



Sisir and his friends geared up for lungi dance!

Having given the JEE at a time when online counselling had still not been introduced, he had to go to IIT Madras to fill up his preferences. There, he came to know about the Energy Science programme launched by IIT Bombay. He had an interest in environment right from his school days but something else sealed the deal. "They had this fancy brochure with wind turbines and solar panels. It all seemed very interesting and exciting so I decided to go for it." Thus, he ended up here instead of mechanical engineering at KGP – a fact his father was

not too chuffed about initially, but quickly got over.

"Best second-years in the institute"

For Sisir and his batch, the first week of every new semester was like opening a mystery box. "For example," he says, "none of us had any idea what a course titled 'Energy Resources, Economics, and Environment' would actually contain. Since it was a totally new programme, each semester, there would be a sense of excitement over what new things we would be learning." The emphasis on breadth over depth in our curriculum, according to him is a double-edged sword. While it makes the students more adept at analysing any system from different perspectives, it also puts them at a slight disadvantage if they wish to specialize and pursue higher education. "After our fourth year, we used to call ourselves the best second-years in the institute."



Sisir and his batchmates dressed up for Kurta Day

Reflecting on his life outside academics, Sisir describes how football was a big part of his five years here, playing in intra-hostel matches as well as the Inter-Hostel General Championship. An erstwhile resident of Penthouse, he fondly reminisces about the wing culture during his days in the hostel. "On the day of Holi, I was sleeping in and had closed the door because I didn't want to be disturbed. However, my wingmates weren't the ones to be deterred. One enterprising guy, went to the balcony adjoining the room next-door, and climbed into my balcony. He had noticed that my window was open, and thus, unlatched my room and woke me up. They made sure that I joined in the festivities."

A tryst with Bill Gates



"A couple of years ago, Bill Gates was looking for innovative projects in the field of sustainability he could fund. The project on artificial photosynthesis I was working on was one of the prospective options Gates was interested in, and Nate Lewis, who was heading it, knew him pretty well. Instead of giving him just a presentation, we invited him to our lab where I taught him to use a razor. Although I was quite nervous when he decided to try it, he handled it really well."

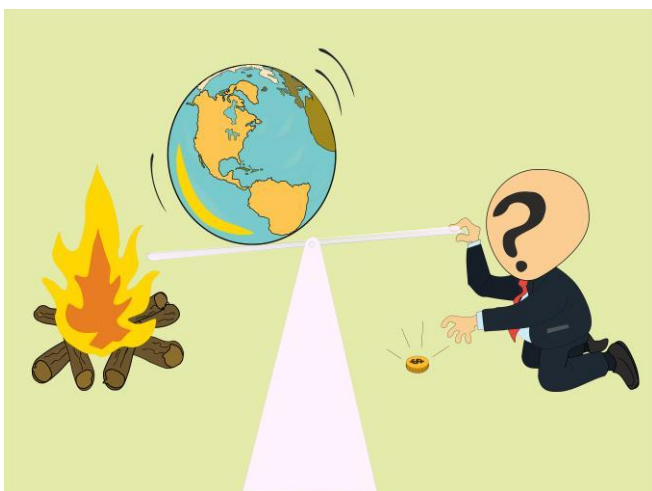
A doctor after all!

Having done research internships in Canada and Israel, Sisir surprised no one when he applied for a doctorate. He particularly feels that having the final year relatively free of coursework helped him focus on the application process. He applied to 10 schools – clearly 9 more than necessary, at least in Caltech's opinion. Post his PhD in Material Science, Sisir has joined KLA where he works on techniques that measure the performance of semiconductor chips.

In hindsight, how has his decision to choose energy engineering shaped him? "On a personal level I have become much better at handling uncertainty and having a go at creative projects which I was scared to do during IIT years. Energy department forces you to do these exploratory projects, I am assuming you still have those."

And any parting advice for his juniors? "You have a lot of alumni in a lot of places unlike our day. I will suggest reaching out and talking to them to understand what all possibilities exist after you are out of there. Always look at the bright side!"

Attention



"Can I grab that? Should I grab that?"

Upcoming Events

- ☐ Energy Day 2020
- ☐ Seminars
- ☐ Resumption of academic activity (Date TBD)



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