Steven Chu

Nobel laureate in Physics 1997

Former United States Secretary of Energy

Stanford University

United States

Thursday, Dec 7, 9.30-10.00

Climate Change and innovative paths to a sustainable future

The industrial and agricultural revolutions have profoundly transformed the world, but the unintended consequence of these revolutions is that humans are changing the climate of Earth. I will briefly describe new data on climate change, before turning to how energy efficiency, carbon-free energy sources and innovation can provide a low-cost path to a more sustainable world.

About the speaker

Steven Chu is the William R. Kenan, Jr., Professor of Physics and Professor of Molecular & Cellular Physiology in the Medical School at Stanford University. He has published over 280 papers in atomic and polymer physics, biophysics, biology, batteries, and other energy technologies. He holds 14 patents, and an additional 6 patent filings since 2015.

Dr. Chu was the 12th U.S. Secretary of Energy from January 2009 until the end of April 2013. As the first scientist to hold a Cabinet position and the longest serving Energy Secretary, he recruited outstanding scientists and engineers into the Department of Energy. He began several initiatives including ARPA-E (Advanced Research Projects Agency – Energy), the Energy Innovation Hubs, and was personally tasked by President Obama to assist BP in stopping the Deepwater Horizon oil leak.

Prior to his cabinet post, he was director of the Lawrence Berkeley National Laboratory, where he was active in pursuit of alternative and renewable energy technologies, and Professor of Physics and Applied Physics at Stanford University, where he helped launch Bio-X, a multi-disciplinary institute combining the physical and biological sciences with medicine and engineering. Previously he was head of the Quantum Electronics Research Department at AT&T Bell Laboratories.

Dr. Chu is the co-recipient of the 1997 Nobel Prize in Physics for his contributions to laser cooling and atom trapping, and has received numerous other prestigious awards. He is a member of the National Academy of Sciences, the American Philosophical Society, the American Academy of Arts and Sciences, the Academia Sinica, and is a foreign member of the Royal Society, the Royal Academy of Engineering, the Chinese Academy of Sciences, and the Korean Academy of Sciences and Technology. He received an A.B. degree in mathematics and a B.S. degree in physics from the University of Rochester, and a Ph.D. in physics from the University of California, Berkeley, as well as 31 honorary degrees.

Katherine Richardson

University of Copenhagen

Denmark

Thursday, Dec 7, 10.00-10.30

How do we transition an entire country's energy system to renewables?

The cost efficient transitioning of a country's entire energy system requires the establishment of a clear vision for how and when the transformation is to be complete as well as a stable policy framework within which relevant market actors can operate to bring about the transition in 2008, the then Climate and Energy Minister in Denmark, Connie Hedegaard, appointed a government commission charged with the mandate of identifying if, when, and how Denmark can become independent of fossil fuels as well as the cost implications of doing so. Based on the Commission's final report (2010), the Danish Parliament adopted the goal of making the country's heat, electricity and transport systems independent of fossil fuels by 2050. The work of the Commission and follow up activities, including the establishment of an advisory Climate Council and its activities, and progress to date are reviewed in this talk.

About the speaker

Katherine Richardson (Denmark) is Professor of Biological Oceanography and Leader of the Sustainability Science Centre at the University of Copenhagen. She was Chair of the Danish Commission on Climate Change Policy which developed the plan for removing fossil fuels from the Danish energy and transport sectors upon which the current national energy strategy is based. She is a member of the Danish Council on Climate Change and a member of the United Nations Scientific Panel to draft the Global Sustainable Development Report, published in 2019. Her research is carried out in the Center for Macroecology, Evolution and Climate and focuses on biogeochemical processes in the surface ocean and how these are influenced by climate change. Specifically, her work deals with how changes in climate and biodiversity in the ocean interact to influence the global carbon cycle. She is also a co-leader in the development of the Planetary Boundaries framework aiming to identify a safe operating space for humanity in relation to its perturbation of the global environment. KR has published over 100 scientific papers and book chapters.

Jean-Marie Tarascon

Collège de France

France

Thursday, Dec 7, 11.30-12.00

Materials science for electrochemical storage: Achievements and new directions

Materials have been essential for improving any energy related technologies including batteries. Identifying new phases, tuning their morphology and mastering their processing into electrodes via the help of evolving analytical techniques have contributed to the success of the Li ion technology and the development of Na ion batteries, which will be illustrated via recent achievements. Will pursuing the same way be sufficient to meet tomorrow's highly evolving demands linked to automotive mobility and others? This is what this presentation will attempt to answer. As personally perceived, the future of battery offers new opportunities for materials scientists as long as we are willing to explore new risky paths.

About the speaker

Jean-Marie Tarascon (1953) is Professor at the College de France holding the chair "Chemistry of solids – Energy). But much of his early career was spent in the United States where he developed (1994) the plastic Li-ion technology. Back to France in 1995, he created the European network of excellence ALISTORE-ERI of which he was head until 2010 when he took over the direction of the new LABEX "STORE-EX". In 2011 he became in charge of the recently created French network on electrochemical energy storage (RS2E). Tarascon's present research is devoted to Li-ion, Na-ion batteries and other chemistries with emphasis on developing new eco-efficient synthesis processes and developing novel reactivity concepts. He is the author of more than 650 scientific papers, and detains about 85 patents. He is member of the French academy of Science and foreign member of the royal society since 2014. He received many honours; the ENI award in 2011, Centenary Prize of the Royal Society of Chemistry's in 2015 with the latest being the Galvani medal from the Italian Electrochemical society and the CNRS innovation medal, both in 2017.

Julia Brown DBE FREng FRS

The Baroness Brown of Cambridge

Vice Chair of the Committee on Climate Change

United Kingdom

Thursday, Dec 7, 13.15-13.45

Electric vehicles in a sustainable energy system

Ultra low emission vehicles – electric vehicles – are a key element of the UK's approach to decarbonising the economy to meet the commitment in the UK Climate Change Act 2008 to achieve at least an 80% reduction in CO_2e emissions by 2050.

The presentation describes how the overarching framework of the Climate Change Act works to drive emissions reduction across the economy, focussing on the particular issues around decarbonisation of surface transport, and the major contribution to emissions from light duty vehicles – cars and vans.

The key issues which must be addressed in delivering a major change in a relatively short timescale, such as electric or hydrogen, impact on the electricity system, battery costs, charging infrastructure, and consumer behaviour, are examined in the context of developing the advice which the Committee on Climate Change provides to the UK Government.

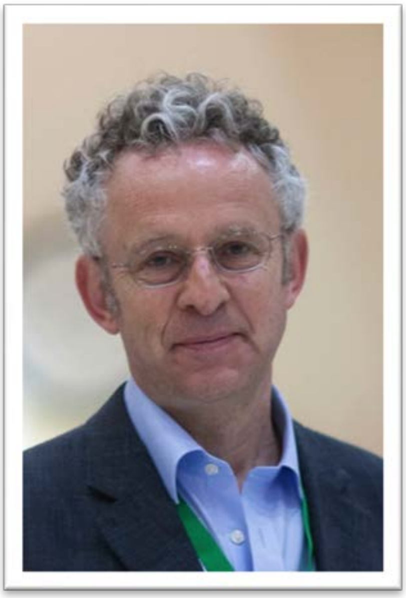
About the speaker

Baroness Brown is an engineer. An academic career at Cambridge University led to senior business and engineering roles at Rolls-Royce plc. Returning to academia as Principal of Engineering at Imperial College, she became Vice-Chancellor of Aston University from 2006 - 2016.

Her current interests include climate change adaptation and mitigation and the low carbon economy. She serves as: Vice Chair of the Committee on Climate Change and Chair of the Adaptation Sub-Committee of the Committee on Climate Change; non-executive director of the Offshore Renewable Energy Catapult; member of the WEF Global Agenda Council on Decarbonising Energy. Former roles include non-executive director of the Green Investment Bank and of Angel Trains. She led the King Review on decarbonising transport (2008), and is the UK's Low Carbon Business Ambassador.

She is passionate about education and engineering: she was a member of the Browne Review on university funding and Lord Stern's review of the Research Excellence Framework. She now chairs STEM Learning Ltd., a not-for-profit company delivering science teacher continuing professional development, and the Henry Royce Institute for Advanced Materials.

She is a Fellow of the Royal Academy of Engineering and of the Royal Society, and was awarded DBE for services to higher education and technology. In 2015 she was elevated to the Peerage as The Baroness Brown of Cambridge. She is a crossbench Peer, and a member of the House of Lords European Union Select Committee.



Sir Richard Friend

Cavendish Laboratory

University of Cambridge

United Kingdom

Thursday, Dec 7, 14.15-14.45

How can molecules function as semiconductors?

Pi-conjugated organic molecules and polymers now provide a set of well-performing semiconductors that support devices, including light-emitting diodes (LEDs) as used in smart-phone displays and lighting, field-effect transistors (FETs) and photovoltaic diodes (PVs). These are attractive materials to manufacture, particularly for large-area applications where they can be processed by direct printing, so that the cost of materials and processing can be very low. This practical success is made possible by breakthroughs in the understanding and engineering of the underlying semiconductor science. The physics of organic semiconductors is often controlled by large electron-hole Coulomb interactions and by large spin exchange energies. I will show how the management of excited state electron spin can be engineered to allow efficient LED and solar cells operation.

About the speaker

Sir Richard Friend holds the Cavendish Professorship of Physics at the University of Cambridge. His research encompasses the physics, materials science and engineering of semiconductor devices made with carbon-based semiconductors, particularly polymers. His research advances have shown that carbon-based semiconductors have significant applications in LEDs, solar cells, lasers, and electronics. These have been developed and exploited through a number of spin-off companies. His current research interests are directed to novel schemes – including ideas inspired by recent insights into Nature’s light harvesting – that seek to improve the performance and cost of solar cells.

Paul Alivisatos

University of California, Berkeley

United States

Thursday, Dec 7, 15.15-15.45

Quantum Dot Light Emitters: from displays to enabling a new generation of energy conversion systems

Nanoscience has provided a new approach for *designing* materials that absorb and emit light and transport charges efficiently. These are fundamental steps that underlie many energy conversion technologies. This presentation will focus on colloidal quantum dots, and how they can be made to absorb and emit light, as well as to transport charge efficiently. When the principles of nanoscience are used to prepare a small piece of semiconductor that is fully isolated from the environment, it can behave as a nearly ideal light absorber and emitter. These “quantum dots” have now left the lab and moved into practical use, as they are widely used today in a new generation of extremely energy efficient displays that provide exceptional color purity. The efficiency of light emission from these quantum dots is so close to unity that it is actually requires new approaches to measure accurately. This in turn has prompted us to investigate what happens when quantum dot light emitters approach the thermodynamic limit of their luminescence efficiency. This talk will describe some entirely new energy conversion processes that may be enabled for the first time by using such nearly ideal light emitters. If time permits, I will also describe recent work on a new approach to extremely efficient ultrafast charge transport in quantum dot films.

About the speaker

Paul Alivisatos is Director Emeritus of the Lawrence Berkeley National Lab and Provost of the University of California, Berkeley. He is the Samsung Distinguished Professor of Nanoscience and Nanotechnology and holds appointments in the Departments of Chemistry and Materials Science at the University of California, Berkeley. He is a founder of two prominent nanotechnology companies, Quantum Dot Corporation (now a division of Thermo Fisher), and Nanosys, Inc.

Groundbreaking contributions to the fundamental physical chemistry of nanocrystals are the hallmarks of Dr. Alivisatos's career. He has elucidated the principles that allow for size and shape- controlled synthesis of nanocrystals, and performed fundamental studies of their structural, thermodynamic, optical, and electrical properties. He demonstrated the application of colloidal quantum dots in light emission devices and in biological imaging.

In recognition of these accomplishments, Dr. Alivisatos has been awarded the US National Medal of Science, the Dan David Prize, and the Wolf Prize in Chemistry.

Josef Michl

University of Colorado Boulder

United States

Institute of Organic Chemistry and Biochemistry Academy of Sciences of the Czech Republic

Czech Republic

Friday, Dec 8, 9.00-9.30

Singlet Fission for Solar Cells

Singlet fission is a photophysical process in which a singlet exciton is split into two triplet excitons. Its use promises to raise the theoretical upper limit of a single-junction solar cell from the Shockley-Queisser limit of about 1/3 to nearly 1/2. Unfortunately, it proceeds efficiently in only very few known materials, and none of these are very practical. We are engaged in a search for and testing of simple structural guidelines for the design of new materials that perform singlet fission efficiently. The lecture will describe a simple rule for finding optimal packing patterns of chromophores into dimers and a procedure for a numerical identification of all local maxima for singlet fission performance in the six-dimensional space of mutual disposition of two rigid bodies (three translations and three rotations), with proper consideration of the effects of Davydov splitting and intermolecular repulsions. A few examples of application will be shown.

About the speaker

Josef Michl was born in 1939 in Prague, Czechoslovakia. M.S. in Chemistry in 1961 with V. Horák and P. Zuman at Charles University, Ph.D. in 1965 with R. Zahradník at the Czechoslovak Academy of Sciences, all in Prague. Michl left Czechoslovakia in 1968, did postdoctoral work with R. S. Becker at the University of Houston, M. J. S. Dewar at the University of Texas at Austin, J. Linderberg at Aarhus University, Denmark, and F. E. Harris at the University of Utah, where he stayed and became a full professor in 1975 and served as chairman in 1979-1984. In 1986-1990 he held the M. K. Collie-Welch Regents Chair in Chemistry at the University of Texas at Austin and subsequently moved to the University of Colorado, Boulder, CO, where he is Professor of Chemistry presently.

Since 2006, he has had an appointment in the Institute of Organic Chemistry and Biochemistry of Czech Academy of Sciences in Prague, Czech Republic.

He has held numerous visiting professorships and named lectureships, delivered hundreds of invited lectures at institutions and conferences, has served on many professional and editorial boards, advisory councils, and committees, and has organized several international conferences. He has been a Sloan, a Guggenheim, a Fulbright, a University of Colorado Faculty, and ACS Fellow, has won the Cope Scholar, Utah Section, Kosolapoff and James Flack Norris ACS Awards, the A. v. Humboldt Senior U.S. Scientist, Japan Society for Promotion of Science, Inter-American Photochemical Society, Hammond, Boron in the Americas, and Wichterle Awards, the Schrödinger and Porter Medals, the J. Heyrovský and Charles University Gold Medals, the Patria award from the Czech government, and the Marinus Smith Award of the University of Colorado. He has honorary degrees from Georgetown University, the University of Pardubice and the Masaryk University. He is a member of the US National Academy of Sciences, and the American Academy of Arts and Sciences, and an honorary member of the Czech Learned Society. He is the President of the International Academy of Quantum Molecular Science. He was the editor-in-chief of Chemical Reviews in 1984-2014, has co-authored five books on photochemistry and polarization spectroscopy, and over six hundred scientific papers.

Susanne Siebentritt

University of Luxembourg

Luxembourg

Friday, Dec 8, 9.30-10.00

Thin film solar cells – achievements and challenges

Thin film solar cells are considered the next generation of photovoltaic technology because of their lower use of materials and energy, compared to conventional solar cells. Additionally, they can be made flexible and light weight, which opens a range of new applications. I will summarise the state of the technology and the latest developments in the research laboratories. The highest energy conversion efficiencies in thin film solar cell technologies above 22% have been achieved by the compound semiconductor $Cu(In,Ga)Se_2$. The understanding of the electronic structure of the semiconductor itself, as well as that of its grain boundaries and interfaces, offer some interesting challenges, which go beyond conventional semiconductor physics. It's been long known that $Cu(In,Ga)Se_2$ shows fundamentally different properties when grown under Cu-rich or Cu-poor conditions. While Cu-rich material has less defects and shows better transport properties, the better solar cells are made from Cu-poor material. This has long been interpreted as due to an interface problem but our recent defect spectroscopies indicate that the problem is already in the semiconductor itself: there is a deep defect that's much more prominent in Cu-rich than in Cu-poor material.

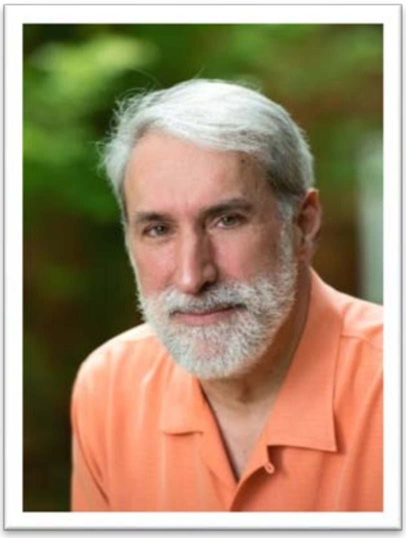
About the speaker

Susanne Siebentritt is a physics professor and heads the laboratory for photovoltaics at the University of Luxembourg.

Her research interest is twofold: the development of new thin film solar cells and the semiconductor physics of the materials used in these cells.

She studied physics at the University of Erlangen and received her doctoral degree from the University of Hannover. After several postdoc positions, she led a group at Hahn-Meitner-Institute for nearly 10 years. In 2007 she moved to Luxembourg and built up the laboratory for photovoltaics.

She is the author of 180 peer reviewed publications, with nearly 4000 independent citations. In 2014 she received the FNR Outstanding Publication Award, together with three co-authors. In 2015 she was awarded the "Grand Prix en Sciences Physique – Prix Paul Wurth" of the Luxembourgish Institut Grand Ducal. Since 2016 she is a board member for the Kopernikus projects, a 10 years research programme for the energy transition of the German Ministry of Education and Research.



Daniel G. Nocera

Harvard University

United States

Friday, Dec 8, 11.00-11.30

Fuels and Food from Sunlight, Air and Water

Photosynthesis uses sunlight, air and water as its only stating materials and creates the world around us. We wondered if we could do the same … using only sunlight, air and water to create a true artificial photosynthesis. We have done so by developing a hybrid biological | inorganic (HBI) system to fix the carbon from carbon dioxide (CO_2) and the nitrogen from dinitrogen (N_2) to accomplish carbon fixation and nitrogen fixation, respectively, thus enabling distributed and renewable fuels and food production. Both carbon and nitrogen fixation cycles begin with the *artificial leaf*, which was invented to accomplish the solar fuels process of natural photosynthesis – the splitting of water to hydrogen and oxygen using sunlight – under ambient conditions. To create the artificial leaf, an oxygen evolving complex of Photosystem II was mimicked, the most important property of which was the self-healing nature of the catalyst. Self-healing catalysts of the artificial leaf permit water splitting to be accomplished under benign conditions and thus the system may be easily interfaced with bioorganisms. Using the tools of synthetic biology, a bio-engineered bacterium has been developed to convert carbon dioxide from air, along with the hydrogen produced from the catalysts of the artificial leaf, into biomass and liquid fuels, thus closing an entire artificial photosynthetic cycle. This HBI, called the *bionic leaf*, operates at unprecedented solar-to-biomass (10.7%) and solar-to-liquid fuels (6.2%) yields, greatly exceeding the 1% yield of natural photosynthesis. Extending our approach, we have discovered a renewable and distributed synthesis of ammonia and fertilizer at ambient conditions by coupling solar-based water splitting to a nitrogen fixing bioorganism in a single reactor. Nitrogen is fixed to ammonia by using the hydrogen produced from water splitting to power a nitrogenase installed in the bioorganism. The ammonia produced by the nitrogenase can be diverted from biomass formation to extracellular production with the addition of an inhibitor. The nitrogen reduction reaction proceeds at a turnover number of 9.1 $\times 10^9$ per cell and operates without the need for a carbon feedstock (which is provided by CO_2 from air). This approach can be powered by distributed renewable electricity, enabling the sustainable fertilization of crops.

The science that will be presented will show that using only sunlight, air and water, a distributed system may be established for the production of fuel and food. Such science will be particularly useful to the poor of the world, where large infrastructures for fuel and food production are not tenable.

About the speaker

Daniel G. Nocera is the Patterson Rockwood Professor of Energy at Harvard University. He is the inventor of the artificial leaf and the bionic leaf. The artificial leaf accomplishes the solar fuels process of photosynthesis—the splitting of water to hydrogen and oxygen with sunlight—and it was named by Time magazine as Innovation of the Year for 2011. He has since elaborated this invention to create the bionic leaf, which takes carbon dioxide from air and combines it with hydrogen from the artificial leaf, to produce biomass and liquid fuels, thus closing an entire artificial photosynthetic cycle that is ten times more efficient than natural photosynthesis. The bionic leaf was named as the Breakthrough Technology of 2017 at the World Economic Forum. He has subsequently elaborated the bionic leaf to create a living biofertilizer for the sustainable production of crops. These science discoveries set a course for the large-scale deployment of solar energy in a distributed fashion, especially for those in the emerging world. He founded the energy company Sun Catalytix and its technology is now being commercialized by Lockheed Martin.

Harry Atwater

California Institute of Technology

United States

Friday, Dec 8, 11.30-12.00

Artificial Photosynthesis: Fuels from Sunlight, Water and Carbon Dioxide

Replacing fossil fuels with renewably generated fuels from sunlight is a grand challenge for humanity. In recent years, considerable progress has been made in discovery of key materials and mechanisms needed to realize artificial solar fuels generators for hydrogen generation by water splitting. I will give an outlook on limits to water-splitting efficiency, scalability, durability and sustainability, and goals for economic viability. Achieving catalytic CO2 reduction at high rates and with selectivity to specific fuel, chemicals and materials is an even larger challenge. I will discuss approaches to achieving selectivity and activity in CO2 reduction electrocatalysis and photocatalysis and recent advances towards this goal.

About the speaker

Harry Atwater is the Howard Hughes Professor of Applied Physics and Materials Science at the California Institute of Technology. Professor Atwater currently serves as Director of the DOE Joint Center for Artificial Photosynthesis. Professor Atwater's scientific interests have two themes: photovoltaics and solar energy as well as plasmonics and optical metamaterials. His group has created new high efficiency solar cell designs, and have developed principles for light management in solar cells.

He also serves as Editor in Chief for the journal ACS Photonics, and is Associate Editor for the IEEE Journal of Photovoltaics, and in 2006 he founded the Gordon Research Conference on Plasmonics.

Professor Atwater received his B. S., M. S. and Ph.D. degrees from MIT respectively in 1981, 1983 and 1987. He has been a member of the Caltech faculty since 1988.