research highlights

ELECTRICITY SAVING IN CHINA

Information beats price

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MICHAEL COYNE/LONELY PLANET IMAGES/GETTY

Residential electricity demand is expected to grow rapidly in rural China, mainly due to increased appliance ownership. The ownership rate of colour televisions increased from 4.7% in 1990 to 116.9% in 2012, while the ownership rates of washing machines and refrigerators changed from 9.1% and 1.2% to 67.2% and 67.3%, respectively, over the same period. Due to such changes, 400 million people living in rural areas will increase their electricity consumption, reaching 2,129 TWh per year by 2030, but little is known about the potential for households to save electricity. Yihua Yu and Jin Guo from the Renmin University of China fill this gap by examining the determinants for saving electricity from 3,404 rural households in China. Rural households are generally found to be efficient in their consumption habits and scarcely affected by electricity price or energy efficiency labelling, whereas information supplied to the consumer about consumption is found to play a significant role.

By using a stochastic frontier model, the researchers were able to decompose residential electricity consumption into two groups: irreducible consumption and consumption slack. Their analysis shows that the presence of alternative energy sources to electricity, and the thrifty behaviour of consumers due to the supply scarcity, makes rural demand respond weakly to price. Therefore, price-reforms policy, planned to curb future energy consumption, might have limited impact and should be accompanied by fast information feedback (detailed energy bills, self-reading meters and home displays) that, instead, tends to promote energy conservation. *AR*

THIN-FILM SOLAR CELLS

Joining the print club

Energy Environ. Sci. http://doi.org/bhwc (2016)

Thin-film solar cells such as those with $Cu(In,Ga)Se_2$ absorbers are promising alternatives to Si solar cells, and now reach efficiencies of over 22%. While the best performing $Cu(In,Ga)Se_2$ devices are produced by relatively expensive vacuum deposition, solution processing can lower the production costs, making thin-film technologies more competitive. Efficiencies of over 15% have been achieved in spin-coated samples, but by means of toxic or unstable inks that are unsuitable for industrial production. Xianzhong Lin and colleagues in Germany and Qatar now report the fabrication of $Cu(In,Ga)Se_2$ solar cells using a drop-on-demand inkjet printing method that is efficient in its use of raw materials and compatible with scalable production processes. Inkjet printing can reduce the material wastage by about a factor of ten compared with spin coating.

A Cu–In–Ga nitrate precursor ink that is stable in air and at room temperature is printed on a substrate and annealed to form a 1-μm-thick compact absorber layer. This layer is not uniform in composition, and is made from a top, thicker layer with large grains, and a bottom layer with smaller grains, which is thought to be inactive. Solar cells fabricated with this absorber have an efficiency of 11.3%, which might be further increased by increasing the thickness of the absorber and optimizing the annealing conditions. *ED*

SOLAR FUELS

Safe and stable splitting

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Photoelectrochemical devices for solar-driven water splitting harness energy from the Sun to produce fuel, in the form of hydrogen. Typically the same electrolyte, which is often a strong acid or alkali, is used in both the cathodic chamber and the anodic chamber of the device where hydrogen and oxygen are generated, respectively. Finding earth-abundant, active components for the electrodes that are stable in the same electrolyte is challenging and many devices can suffer from poor stability. Chengxiang Xiang, Nathan Lewis and colleagues at the California Institute of Technology now report a safe, stable, integrated device with a large photoactive area (>1 cm^2) that makes use of a bipolar membrane to allow solutions of different pH to be used in each chamber, achieving a solar-to-hydrogen efficiency of 10%.

By matching the electrode components to the appropriate electrolyte in terms of chemical stability (cathode — acid; anode — alkali), the researchers were able to demonstrate stable operation for over 100 hours for a device consisting of an oxide-protected tandem-junction photoanode (GaAs/InGaP) coupled with a nickel catalyst for oxygen evolution, separated from the cobalt phosphide-based cathode by a commercially available bipolar membrane. The membrane maintains a steady pH gradient and due to its low permeability to both hydrogen and oxygen, there is little crossover between the products, mitigating the risk of formation of explosive gas mixtures. *JG*

CARBON DIOXIDE CAPTURE

Multiple site absorption

Angew. Chem. Int. Ed. http://doi.org/f3mrc9 (2016)

To limit CO_2 emissions, it is imperative to develop efficient technologies for CO_2 capture. Ionic liquids (ILs), especially those based on amino acids, have emerged as promising CO_2 absorbents in which CO_2 chemisorption can occur at the amino groups. However, the carboxylate groups in amino acid ILs are not able to absorb CO_2 because the presence of amino groups reduces their alkalinity, and thus their affinity for CO_2, through the electron-withdrawing inductive effect. Duan-Jian Tao, Sheng Dai and colleagues in China and the USA have now designed aminopolycarboxylate-based ILs that feature multiple acetate groups attached to the nitrogen of the amino groups, which activates the carboxylate groups leading to exceptionally high CO_2 absorption capacity (up to 1.69 mol CO_2 per mol IL).

The idea behind their molecular design was to use acetate groups, also electron-withdrawing species, to mitigate the negative inductive effect of the amino groups, allowing the carboxylate groups to interact with CO_2 more effectively. Calculations showed that in conventional amino-acid-based ILs, the oxygen atoms of the carboxylate groups have reduced negative charges once a CO_2 molecule is absorbed. In aminopolycarboxylate-based ILs, on the other hand, the nitrogen atoms of the amino groups have significantly reduced negative charges while the oxygen atoms of the carboxylate groups remain largely negative so that further CO_2 molecules can be absorbed at the carboxylate sites. *CZ*

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