leak to BuzzFeed, a news website, of government forecasts showing that any model of Brexit would cut economic growth as just more scaremongering, some must worry that the forecasters will be right this time. Most alarming is the analysis that trade deals with third countries would do little to offset lost trade with the EU.

The response of Brexiteers has been to coin an acronym for something they are determined to prevent: BRINO, or Brexit in name only. Many were incensed when the chancellor, Philip Hammond, told business leaders in Davos that, although Britain might diverge from the EU, the differences would be "very modest". Mrs May's office promptly said that leaving the single market and customs union could not be described as very modest steps. But Brexiteers now have Mr Hammond, and maybe Mrs May and her adviser Olly Robbins as well, in their sights.

The mood in Parliament is febrile. This week the House of Lords began its debate on the EU withdrawal bill. Even many Tory peers criticised the excessive powers it confers on the government. Several also called on Mrs May to be clearer about her end-goals. Many MPs expect the Tories to do badly in local elections in May, especially in anti-Brexit London. The prime minister could yet survive all the plots against her, not least because she has no obvious successor. But there is a risk that Parliament may vote down any Brexit deal she reaches this autumn. The biggest fear for Brexiteers may not be of a soft exit—but whether Mrs May can deliver any Brexit at all. ■

Theresa May in China

Macartney's heir

BEIJING

The prime minister's awkward visit shows Britain's weakened clout

IN 1793 the leader of Britain's first mission to China, George Macartney, refused to kowtow to the emperor. His attempt to maintain Britain's dignity, however, was rather undermined by the message written on the sails of the imperial junks that transported his diplomats and trade goods to Beijing. This read: "Ambassador bearing tribute from the country of England".

Dealing with the Chinese government is rarely easy, as Theresa May found during her three-day visit to the country this week. The prime minister had a difficult balance to strike. For one thing, she wanted to reassert that Britain and China are still enjoying the "golden era" proclaimed in 2015 by Xi Jinping, China's president, and her predecessor, David Cameron, who since leaving office has been trying to set up a China-Britain investment fund.

She also wanted Britain to become more closely involved in the Belt and Road Initiative, a $4trn network of infrastructure projects that is Mr Xi's signature foreign policy and the focus of Mr Cameron's fund. To that end, she has already—as she sees it—done more than other rich countries to cosy up to the scheme. Her chancellor, Philip Hammond, has appointed a "City envoy" to it (Douglas Flint, a former chairman of HSBC) and set up a "City board" to try to bring the financing of belt-and-road projects up to rich-world standards of transparency (good luck with that). Above all she needed to show, by improving ties with China, that her talk of a global Britain open for business after Brexit is not just waffle.

Mrs May (right) and friend

Like Macartney, Mrs May would prefer to get all this without kowtowing. She also knows that European countries are wary of the opaque financing of belt-and-road projects, and suspicious of China's use of the scheme to expand its influence in central and eastern Europe. America's administration has dubbed China a "strategic competitor". This means Mrs May cannot bend over backwards to buy her host's acquiescence without offending Europeans and Americans.

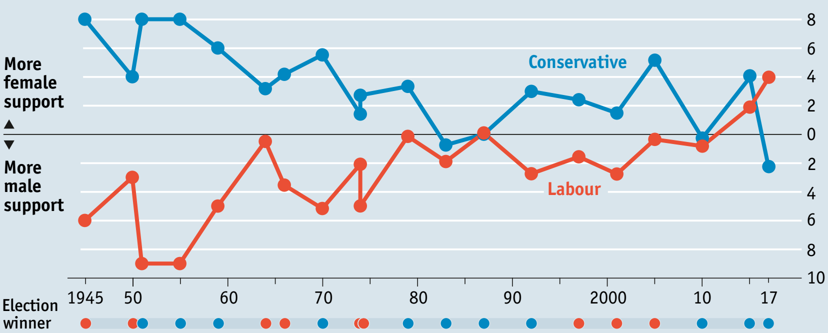
If she had hoped the Chinese government would let her off the hook by not demanding too much in exchange for her wish-list, she was soon disappointed. The Chinese asked her formally to endorse the Belt and Road Initiative by including flattering words about it in various memoranda of understanding. They also wanted Britain to support Mr Xi's attempt to present himself as a leader of globalisation by embracing his buzz-phrase about a "shared future for mankind".

All this went too far. Mrs May gamely spoke of the "British dream", echoing Mr Xi's slogan of a "Chinese dream", and tactfully avoided the subject of human rights, at least in her public remarks. But she turned away from happy talk about a "golden era" and gave warning that China needed to respect international trading rules more. Perhaps Mr Xi supposed Mrs May was so weak domestically that she would have to give in to Chinese pressure. But perhaps she was so weak that she could not. ■

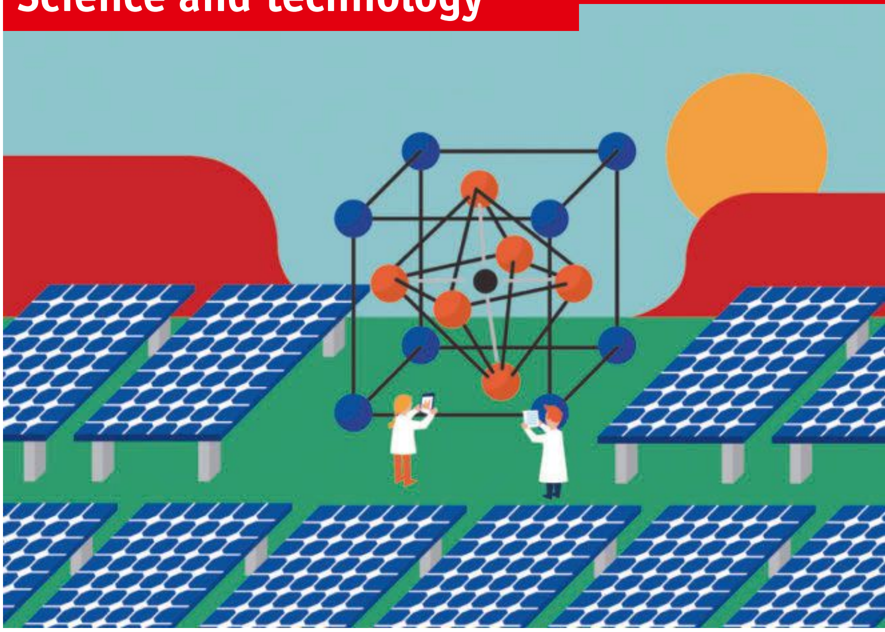
History lessons

On February 6th Britain will celebrate a century of female suffrage. The movement had a cautious beginning. In 1918 voting rights were extended only to women over 30 who owned property or were married to a man who did. Universal suffrage came a decade later. The conservative men who passed the law of 1918 feared electoral defeat if they opened the ballot boxes to "flappers", the young women who wore short dresses, heavy make-up and bob haircuts and had scandalously liberal social attitudes. In reality, women's voting habits turned out to be more conservative than men's—and more or less stayed that way until last year. If men alone had voted, Labour would have won the elections in 1955, 1959 and 1970. The Tories prevailed in all three because they won the female vote by a margin wider than the tasselled hem of a flapper's skirt.

Britain, general elections, difference in male and female vote share by party, percentage points



Sources: *Critical Elections: British Parties and Elections in Long-term Perspective*, G. Evans and P. Norris, 1999; Rosalind Shorrocks; British Election Study



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Solar energy

Helios's crystal

Solar cells made from perovskites are coming to the market

SOMETIMES it takes a while for the importance of a scientific discovery to become clear. When the first perovskite, a compound of calcium, titanium and oxygen, was discovered in the Ural mountains in 1839, and named after Count Lev Perovski, a Russian mineralogist, not much happened. The name, however, has come to be used as a plural to describe a range of other compounds that share the crystal structure of the original. In 2006 interest perked up when Tsutomu Miyasaka of Toin University in Japan discovered that some perovskites are semiconductors and showed particular promise as the basis of a new type of solar cell.

In 2012 Henry Snaith of the University of Oxford, in Britain, and his colleagues found a way to make perovskite solar cells with an efficiency (measured in terms of how well a cell converts light into electric current) of just over 10%. This was such a good conversion rate that Dr Snaith immediately switched the direction of Oxford Photovoltaics, a firm he had co-founded to develop new solar materials, into making perovskites—and perovskites alone. Progress has continued, and now that firm, and also Saule Technologies, a Polish concern founded in 2014 to do similar things, are close to bringing the first commercial perovskite solar cells to market.

Today 10% is quite a modest efficiency for a perovskite cell in the coddling conditions of a laboratory. For lab cells values above 22% are now routine. That makes those cells comparable with ones made from silicon, as most of the cells in solar panels are—albeit that such silicon cells are commercial, not experimental. It did, however, take silicon cells more than 60 years to get as far as they have, and the element is probably close to its maximum practical level of efficiency. So, there may not be much more to squeeze from it, whereas perovskites could go much higher.

Perovskite cells can also be made cheaply from commonly available industrial chemicals and metals, and they can be printed onto flexible films of plastic in roll-to-roll mass-production processes. Silicon cells, by contrast, are rigid. They are made from thinly sliced wafers of extremely pure silicon in a process that requires high temperature. That makes factories designed to produce them an expensive proposition.

Racing with silicon

On the face of it, then, perovskites should already be transforming the business of solar power. But things are never that simple. First, as with many new technologies, there is a difference between what works at small scale in a laboratory and at an industrial scale in a factory. Learning how to manufacture something takes a while. Also, perovskites as materials are not without their problems—in particular, a tendency to be a bit unstable in high temperatures and susceptible to moisture, both of which can cause the cells to decompose. Such traits are unconducive to the success of a product that would be expected to last two or three decades in the open air. Researchers are beginning to solve those shortcomings by making perovskites that are more robust and waterproof.

But even if they succeed, there is a third consideration. This is that these newfangled cells will have to go up against an incumbent solar-power industry which invested $160bn in 2017 and is familiar with silicon and how to handle it.

What perovskites need, then, is a record which would provide that industry with the confidence to use them. To do this, both Oxford Photovoltaics and Saule are teaming up with large companies to ease the new materials into the market quite literally on the back of established products.

In the case of Oxford Photovoltaics those established products are existing silicon solar cells. The idea behind the resulting so-called tandem cells is that together the two materials involved can mop up more of the spectrum and turn it into electricity. This is done by tweaking the perovskite upper layer to absorb strongly at the blue end of the spectrum and leaving the lower silicon layer to capture those wavelengths falling towards the red end. That boosts the efficiency of the combined panel by 20-30% says Frank Averdung, Oxford Photovoltaics' boss. Tandem cells of this sort would allow solar-panel producers to offer a performance beyond anything silicon alone might achieve. Such panels would, of course, cost more to make—but the boost in performance will not, Mr Averdung says, increase the cost per watt and in time may reduce it.

Oxford Photovoltaics is now building a production line in Germany to start making tandem cells next year with what it describes as standard industrial processes. ▸▸

The factory will be used to demonstrate the technology, which will then be licensed to other manufacturers. Some of the details are still secret, because the company is working with a large but unnamed solar-energy firm.

The tandem approach lowers the barrier to perovskites entering the market, and allows the new materials to be shown to meet various industry standards. It is, though, intended only as a halfway house. Eventually, Mr Averdung believes, perovskites will act as stand-alone cells—and not just in conventional panels. Because they are semi-transparent, perovskite films could also be used to turn windows into solar generators, by capturing part of the incoming sunlight while permitting the rest to pass through.

Saule, meanwhile, is using inkjet printing to produce its own perovskite cells on thin plastic sheets. At present it can turn these out in A4 size (210mm by 297mm), but it is scaling up the process to manufacture versions with an area of one square metre. Saule's sheets have an efficiency of 10%, so are not yet a match for the sorts of silicon panels found in solar farms. But Artur Kupczunas, a co-founder of the company, says that in combination with the cheapness, flexibility and lack of weight of perovskite sheets, an efficiency of 10% is enough to justify applying those sheets to the exteriors of buildings. The established products that Saule is hoping to ride on the back of are thus the components used to construct those exteriors.

The power of the press

To this end, Saule has granted Skanska, one of Europe's biggest construction groups, the right to incorporate perovskite printed sheets into some of its components, such as those used to make façades. This would let the walls generate electricity, thus lowering a building's carbon footprint and making it more self-sufficient. Skanska plans to test the sheets on an office block, possibly in Poland, later this year.

As the sheets would be added to their substrates off-site, there would, Mr Kupczunas points out, be no additional installation costs. In time, he expects sheets' efficiencies to increase towards the 26% which the company has achieved in laboratory conditions. The printing process also makes it easy to produce sheets of different sizes for different applications. They should function better than silicon in low light, which means they would generate more electricity on cloudy days.

Perovskites are thus now serious challengers to silicon solar cells. That does not mean they will succeed. The history of technology, in this area and in others, is littered with ideas that looked good (and, indeed, were often technically superior to existing alternatives) but nevertheless fell by the wayside. The power of incumbency should not be underestimated. And the price of silicon-based solar power has dropped markedly over the past decade, particularly as a consequence of enormous investment by the Chinese.

Nevertheless, as Sam Stranks, who leads an optical-electronics research group at the University of Cambridge, observes, the demand for renewable power is such that a huge ramp-up in production will be needed. He believes perovskites have every chance of sharing in this, both because they are cheap and because he thinks that one more turn of the technological ratchet will improve their efficiency in a way that silicon cannot match.

Because many chemical combinations result in a perovskite crystal structure, and each of them has different optical properties, choosing the chemistry of a cell also means choosing what part of the spectrum it absorbs, as Oxford Photovoltaics is doing already with its tandem silicon-perovskite cells. Dr Stranks thinks that in time silicon could be cut out of the loop by making tandem cells entirely out of layers of perovskites. This, he reckons, could push efficiency levels up to around 36%. And if that happens, it really might drive silicon solar cells into the shadows. ■

A Severn barrage

The wheel turns

An old idea might at last be made practical by an old idea

COMPARED with solar and wind energy, which are booming, tidal power is an also-ran in the clean-energy stakes. But if you did want to build a tidal power station, there are few better sites than the estuary of the River Severn, in Britain. Its tidal range, the difference in depth between high and low tides, of around 15 metres is among the largest in the world.

Engineers and governments have been toying with the idea since at least 1925. But none of the proposed projects has materialised. Price is one objection. A study by Britain's National Infrastructure Commission, published last year, reckoned that tidal energy might cost between £216 and £368 ($306-521) per MWh of electricity by 2025, compared with £58-75 for seagoing wind turbines and £55-76 for solar panels. Environmentalists also worry that any plant would alter the tides it was harnessing, making life harder for wildlife.

As he describes in a paper just published in the *Proceedings of the Royal Society*, though, an engineer called Rod Rainey thinks he has a way around both problems. He proposes to replace the conventional turbines of previous planned schemes with a much older technology. Specifically, he plans to span the estuary with a line of breast-shot water wheels. This is a design that dates back to the early days of the Industrial Revolution. Examples can be found fixed to the sides of picturesque old watermills.

But there would be nothing old-fashioned about Mr Rainey's wheels. Thirty metres high and 60 wide, they would be made, in shipyards, from ordinary steel. Two hundred and fifty of them, along with the necessary supporting structures, would be floated into place and secured to the seabed, creating a line 15km long. Together, they could supply power at an average rate of 4GW. That is about as much as two biggish nuclear power stations would manage. Substituting one of the wheels with a set of locks would provide a shipping channel about twice the width of that through the Isthmus of Panama, permitting upstream ports such as Avonmouth and Cardiff to continue operating.

On paper, at least, Mr Rainey's scheme looks attractive. Some of its advantages are environmental. The "breast" in a breast-shot water wheel is a structure on the river-bed (or, in this case, the seabed) that forms a near-watertight seal with the vanes on the bottom of the wheel. This means that if a motor is used to reverse the direction in which the wheel is turning, it will act as a pump instead of a generator. By pumping at the right points in the tidal cycle, such a system could minimise the impact on water levels behind it, helping preserve wetlands and other desirable habitats. Conventional turbines turn quickly, mincing any fish that come too close. Mr Rainey's water wheels, by contrast, would revolve