How to profit from the Smart Energy Revolution
We’re on the cusp of a revolution in the energy industry.

It’s one that could **redraw** the energy map of the world...

Give humanity the ability to tap essentially **unlimited** power sources...

And – if you make the right investments – make a **fortune** for investors.

In short, we’re living through a step change in the way the world produces and consumes energy. It is a transition that’s well under way. And it’s being driven by the convergence of several key technological trends that are showing no sign of abating.

**The solar century**

I’m talking, of course, about the shift away from fossil fuels like oil, coal and natural gas and towards a world powered by solar energy.

Solar is something that I’m certain you already have some pre-existing ideas or biases about. Most people do. For some, it’s the breakthrough that has promised so much for so long... and never delivered. For others, it’s a bureaucratic mess – an industry supported by government subsidies and handouts. Other people just can’t imagine how something like solar could ever challenge the supremacy of oil.

All I ask is that you put all those ideas aside for a second and give me five minutes to show you what makes this industry so exciting right now. Let’s get straight to it. Solar sits at the apex of two hugely powerful trends, both of which have the capacity to turn the industry on its head. I call these:

1) **The “exponential energy” trend**

And

2) **The invention of “solar pipelines”**

Let’s dig straight into what they mean.

Chances are you know what an exponential curve looks like. An exponential progression, for instance, something doubling every year, tends to track a linear one until it hits the “knee of
The curve” and explodes upwards, like this:

![Graph showing exponential growth in solar energy installations and decreasing cost per watt.](image)

The most famous exponential trend in the technology world is probably Moore’s Law. It states the computer processing power doubles roughly every 18 months. That’s the driving force that makes technology faster, smaller and cheaper all the time.

But there’s a parallel to be drawn with the solar energy industry. The cost of a solar energy power unit is falling in price dramatically. And at the same time, its efficiency is increasing. That means we’re able to capture **more energy** for a **lower cost** all the time.

This is something that futurists like Ray Kurzweil have been predicting for years. As he told Big Think in a 2010 interview:

*Solar panels are coming down dramatically in cost per watt. And as a result of that, the total amount of solar energy is growing, not linearly, but exponentially. It’s doubling every 2 years and has been for 20 years. And again, it’s a very smooth curve.*

*There’s all these arguments, subsidies and political battles and companies going bankrupt, they’re raising billions of dollars, but behind all that chaos is this very smooth progression.*

That was six years ago. But in the time since, the trends that Kurzweil described have been accelerating. Look:

![Graph showing decreasing price per watt and increasing global solar panel installations.](image)

*Source: Earth Policy Institute/Bloomberg*
The price of solar energy has collapsed. That's led to an explosion of new installations.

The reason those trends appear so dramatic is because the numbers go back 40 years. But narrow your focus to the last few years and the trend is the same. This chart describes the trend nicely:

![Chart showing trend in solar energy prices](source: www.seia.org)

The price per watt of electricity generated by solar has more than halved in the last decade. Installations have increased six fold since 2010.

The chart tells the story. Falling prices allow increasing numbers of people to use solar energy as a viable energy source.

And that's exactly what they've been doing:

![Pie chart showing energy capacity](source: www.seia.org)

These figures are from 2014 (the latest data set available through the Solar Energy Industry...
What the above chart shows is the percentage of new energy installations coming on stream broken down by sector. Solar energy outstripped every other new supply.

All three charts tell the same story. The trends at work in the solar industry right now are driving it towards a moment of critical mass – when the price has fallen sufficiently and enough capacity has been installed that the entire industry takes off.

That's important. Because there's an absolute vast amount of solar energy out there for the taking.

As award winning author and chairman of the XPRIZE Foundation Peter Diamandis puts it: “We live in a world bathed in 5,000 times more energy than we consume as a species in the year, in the form of solar energy.”

Or to put it another way (in the words of author and solar expert David S. Findley):

“The sun provides more energy in one hour than all humanity uses, in all forms, in a single year. Sunlight can provide us with its own resolution to our energy problems.”

I'm sure there is some theoretical limit to how much energy there is in the universe. But the more pertinent point is: that limit is so far beyond what humanity needs that it may as well be infinite.

The breakthroughs we've seen (falling cost and increasing efficiency) are two of the key reasons our Investment Director Eoin Treacy believes 2016 could be the year for solar. As he told Exponential Investor readers recently:

I saw back in 2010 that unconventional oil and gas were going to be game changers for the energy sector. That is now all in the price with oil contracts tracking their credit crisis lows. And yet this pales in comparison with what is coming down the pipe with the innovation that's occurring in renewable energy. Shale oil and gas brought energy prices down and renewables will help keep them down. However, the technological innovation that is driving the sector forward works independently of commodity prices. Bad news means nothing to scientists coming up with the next big thing.

And there are signs that 2016 could be the “lift-off year”.

The world's largest manufacturer Hon Hai Precision (more commonly called Foxconn) with more than 1,000,000 workers, used the Christmas holiday to announce its attempt to acquire Sharp. The mainstream media are covering this as if it is only about flat screen TVs, but that lacks imagination and particularly because Sharp manufactures the world's most efficient solar cells. For a sector where the promise of complete independence from utilities is real, it seems downright silly to ignore Sharp's solar business. I view this development as a sign of big things to come in the solar sector, not least because Hon Hai has never manufactured under its own brand before.

On top of that, the US government announced in December 2015 that the subsidies available to renewable energy companies will be renewed for another five years. For a sector innovating at this pace that is plenty of time to be able to survive without...
assistance.

So what does all this mean?

In short, as solar cells become more affordable while also becoming more efficient the number of uses to which they can be put will multiply. Curtains will no longer be required because solar coating on windows will have a customisable Polaroid effect that will also power your tablet. Our cars will have cells on their ceilings and bonnets so batteries can be charged on the go. Utilities will face competition from major real estate owners such as offices and supermarkets, because they will have the ability to generate electricity within close proximity of major populations.

It doesn’t matter how efficient your solar or wind generators are if you can’t store the power once it’s been created. That’s why renewable energy and batteries have a symbiotic relationship. Batteries didn’t get the kind of R&D [research and development] capital that could make a difference until energy prices shot up and everyone started looking for alternatives.

“Solar pipelines”

The energy is there. And our ability to tap it in an efficient way and at a reasonable cost is moving rapidly in the right direction. What’s the final piece in the puzzle?

Enter battery technology.

Battery technology is a vital component in the renewables industry. Batteries are to renewables what pipelines and tankers are to the oil and gas industry. One cannot function without the other.

In fact, battery technology could well be the key that makes solar viable. It allows us to transport energy from the places we capture it and towards the places we need to consume it. As I said, it’s as important to the industry as a pipeline is to the oil and gas sector.

But what battery technology is most viable? How does it work? And where are the opportunities amongst the firms leading the charge?

That’s what I asked one of our contributors and renewables expert Andrew Lockley to answer for you. In fact, he’s put together an extensive guide to the key players when it comes to battery tech. I’ll hand you over to Andrew now to explain:
Storing sparks - how batteries will change electricity forever

Andrew Lockley
Exponential Investor

Power has a problem – a very big problem.

As we’re moving from the fossils age to a world of low-carbon electricity, the whole way we handle electricity needs to change. In fact, it has to change. And there’s evidence this change is already underway. Chances are it’ll throw up opportunities and risks in equal measure. It’s like getting divorced from an even-tempered wife (albeit a chain-smoking one), and moving in with a tempestuous but beautiful young mistress.

As you may well know, renewable energy sources are becoming more and more viable. The consequences of clean, predictable and virtually limitless sources of energy – in politically stable locations – could be revolutionary for mankind. I’m personally very clear that solar will be the revolutionary technology that powers coming decades.

The problem is, renewables generate when they damn well want to. Something as trivial as a large cloud blowing over a major solar farm can cause appreciable grid disruption. Added to that, there’s a need to smooth out the more predictable mismatch between supply and demand that occurs on a daily or seasonal basis.

Today we’re going to focus on a technology that’s ideal for handling the hourly and daily ebb and flow of power generation. This is something you’ll be very familiar with – the battery. It’s a vital piece in the renewables puzzle.

The battery revolution

Let’s cover the basics. Batteries are pretty simple. You charge them up, then they’re full of power when you need them. To plug them back into the mains as a source of power, you need a bit of kit called an inverter – but it’s nothing particularly troublesome (you can buy small ones in garages, for charging your laptop).

As far as the grid is concerned, a battery is just another power station. As long as there’s a way to switch it on when the power is needed, then a battery is every bit as good as a diesel generator or a nuclear power station (while it lasts). Obviously, like any energy storage technology, batteries get depleted. But charging them up again is all part of the fun – because in the dead of night, when the wind is blowing hard, too much power can be as much of a problem as too little.
The most basic type of grid batteries are just like the ones in your car or laptop. These are most likely lithium-ion, or Li-ion. They just sit there, in a box, charging and discharging at will. And they can be scaled up in arrays the size of power stations. AES has deployed serious power plants, using exactly this technology – with its largest battery array now capable of pumping 200mw back to the grid (that’s half the electricity demand of Malta).

You’ll almost certainly have heard of the excellent Tesla. Not only is Telsa making great strides in electric vehicles, it also owns its own battery manufacturing plant – a colossal 1,000 acre “Gigafactory”, which aims to make a serious dent in worldwide battery demand. This is a huge joint-venture project in Nevada, with Panasonic.

Remarkably, the technology being used is actually pretty basic, and the Li-ion cells Panasonic is making are fairly bog standard – but it is relying on massive scale to get costs down.

And as with so many of Elon Musk’s ventures, it’s already looking successful. Despite their enormous ambition, they still haven’t been able to keep pace with demand – and their grid-connected battery (made in the same factory as their vehicle batteries) has proved wildly successful.

This “Powerwall” battery can be used in various different ways. Firstly, it can be configured as a backup battery – useful if you need to bridge a power cut but not really our concern here.

Secondly, you can use it for grid arbitrage or to store solar at your home. This means you can take cheap electricity (eg, at night in windy countries or noon in sunny ones) and use it in the evening, when electricity is expensive.

Finally, if you’re a grid energy company, you can buy vast arrays of these Powerwalls to stick in a warehouse – performing much the same trick – but the other side of the meter.

Even better, if you’ve got a renewables farm way off the grid, you can use the batteries to suck up electricity at your peak output – so you don’t have to pay for a huge cable to bring your electricity onto the grid. Instead you can use just a much smaller and cheaper one.

For utility use, Tesla’s Powerwall is similar to many other competing providers, and we’ll look at those later. Gaelectric is using Tesla’s batteries in a big array. This forward-looking technological approach makes Gaelectric an interesting utility play, as it’s well-placed to take advantage of the renewables revolution.

However, Tesla is just so far ahead of the game in terms of scale, and has so many other angles to its business model, that it’s really hard to see anyone catching up in this market.

But for all that, lithium-ion batteries aren’t perfect.

They’re pretty good at storing energy, but they don’t like releasing it in a hurry – which is why you’ve still got that heavy old lead-acid battery in your car. And, as you’re likely familiar with, Li-ion batteries don’t last forever. While software helps reduce wear and tear, they aren’t really suited to being charged and discharged rapidly. Furthermore, they’re pretty pricey – which makes storing a lot of power a challenge. Therefore, if you’re a utility looking to install some serious medium-term storage capacity – the kind that could get you through a chilly, calm week in winter, then you’ll probably want to look at a completely different type of battery.
What else is out there?

There's a bit of choice here. Firstly, you can look at conventional batteries that use different chemistry. One example is the sodium-sulphur battery. Unlike Tesla's offering, these aren't good house guests. They run at very high temperatures, so you certainly won't be sticking one on your wall any time soon. But they're cheap – and although Li-ion is crashing in price, presently the cost advantages are still with this NaS technology.

Another choice for bigger applications is the flow battery – and it's this technology that I find particularly exciting. Flow batteries are different from the batteries you're used to – they usually use two different electrolytes, one for each battery terminal.

These are pumped through the battery and stored in large tanks. In principle, the tanks can be made as big as you want them to be, although there are obvious commercial limits. For very long-term storage (eg, storing summer solar power for winter), converting renewable electricity to flammable chemicals is likely much more economical – and that's a competitive problem for the longer-term battery firms.

If you'd like exposure to firms with flow-battery technology, EnSync Energy and Prudent Energy both make systems. Again, these cheaper technologies are great for bridging a windless or sunless week. But there's a problem: the risk for the longer-term battery players, such as flow batteries, is that they'll get squeezed on one side by the falling cost of short-term Li-ion, and on the other side by the increasing practicality of power-to-fuels technology – which we'll deal with in another piece.

Picking winners is tricky at the best of times. If you're finding the whole business of battery choice a little confusing, you can even try Younicos – who will build the hardware and software you need to run any kind of utility battery.

But if you'd ask me where I'd put my battery cash, I wouldn't hesitate to answer: Tesla. It is going to eat the world. Check out this chart to see how fast Tesla’s chosen Li-ion chemistry is falling in price, as the technology scales.

Source: PV Magazine
Sure, you can bet on competitors. Imergy’s flow batteries can likely be made to last longer. Eos’s product is (at present) significantly cheaper technology than Tesla’s. But the cost of lithium-ion battery storage is on the crucial downward trend, and Tesla is the biggest beast in the market. It’s inevitably going to be a very strong performer in future storage markets.

Furthermore, even if this energy-storage judgement call is wrong, Tesla’s still got those lovely cars to fall back on. But do keep an eye on flow batteries – although they’re much more risky, they could end up proving to be a winner in storage – particularly beyond the daily timescale. You can also take a look at some of the competing battery chemistry, but with Li-ion scaling so fast I think it’s risky to bet against it.

Finally, as an alternative way to play Li-ion, maybe look at a technology firm – such as 24M. This emergent outfit has come up with a way of making high-performance Li-ion batteries, without using the fiddly thin-layer construction that Tesla relies on.

So what do you think? Have I called Li-ion as the technology of choice for the mid-term? I’m with Elon Musk on this. Are you?

**Introducing: compressed air energy storage**

Energy storage will unlock the renewables revolution. I’ve already looked at the increasing role of battery technology. That leaves two more options for the short-term storage of renewable power: compressed air and flywheels. Today we’ll be taking a “deep dive” into compressed air. Then, next week I’ll complete this storage mini-series by looking at flywheels.

First, let’s look at where compressed air energy storage (CAES) fits into the mix. (For clarification, there’s a range of fundamentally similar technology, called “pumped heat electrical storage” (PHES) and “liquid air energy storage” (LAES). We’ll use CAES in the early part of the article to cover all three, but we’ll pick out specific firms later using the proper designation.)

Broadly speaking, you need energy storage to do three things. Firstly, you need to shave the minute-by-minute peaks and troughs – like when everyone switches on the kettle together (eg, during an ad break in Coronation Street). Then, you need to deal with the fairly predictable daily ups and downs in energy usage – wind turbines keep going at night, when everyone’s asleep, and solar is done by 10pm, when everyone’s still watching TV. Finally, you need to balance out seasonal demand – because your solar is dead by 4pm in winter, but your peak load hasn’t even started yet. Unless you are going to install lots of spare generating capacity, you need to somehow bring summer solar into the depths of winter.

Fundamentally, compressed air is great for the middle one. It’s not quite fast enough to start to deal with little demand bumps (flywheels may turn out better, and batteries are likely faster). And it hasn’t really got the kind of capacity to get you through the long dark winters (chemical storage is better). But it will keep on blowing every day, when the wind’s died down or the sun’s gone to bed.

But there’s more...

If you’re a renewables generator, particularly wind, you’ll have a problem. Your wind turbine
is likely stuck on some Godforsaken hilltop or out in the middle of the sea. Onsite energy storage cuts the price of the big fat cable you need to lay. Better sale prices and lower capital costs. What’s not to like? Iowa Stored Energy Park is taking just this approach – putting storage right next to the renewables. For an offshore wind focussed version of the technology, check out Nimrod (UK), or Hydrostor (Canada) – which we’ll discuss in more depth later.

So how does it work?

Fundamentally, all you need is a big cave, a compressor and a turbine. When electricity’s cheap, you blow air into the cave with the compressor. When electricity’s expensive, you let it out through the turbine, which powers a generator. Simples. (The PHES/LAES are slightly different, working on heat, not pressure, for storage).

What about the economics?

There are two fundamentals things you need to be aware of. Surprisingly, CAES is really not very good. The amount of energy recovered from a compressed air installation might only be up to 2/3 of what you put in. Current battery arrays can manage about 85%, so they’re a lot better. So why would anyone bother? The simple answer is that it’s really very cheap to build. Furthermore, the technology is super simple – especially for the less sophisticated installations. This means it doesn’t break, so it’s got a good life expectancy, and thus a low “levelised cost”. This cost profile means you can soon expect to “blow” electricity into a hole for 4c per kWh, then retrieve it. So if your peak price is higher than your baseload by as little as 4c (plus efficiency losses), that’s a trade worth doing. Those numbers are already attainable – and the gap will only get bigger as we shift to mass renewables.

Sadly, suitable caves aren’t all that common – and firms such as Gaelectric are currently on the hunt for suitable locations. They’re going to be using an aqueous salt mining technique to create a massive empty bottle in the rocks, a kilometre below the Northern Ireland coastline. If you’d prefer a stateside play, try New York State Electric and Gas, which is going for similar salt cavern technology.

Of course there’s a bit more to the technology than that, and there are several technology variants. You can make small-scale units that rely on artificial gas bottles – great if you want modular storage that fits in a shipping container. If you’re currently stuck for caves, you can pump water into bags under the sea. Remarkably, this technology is already pretty long in the tooth – which means it’s reliable and bankable. The first large-scale installation went up in the 70s, and McIntosh (Alabama) and Huntorf (Germany) currently own plants. You don’t need renewables to make it work –nuclear baseload energy is also super-cheap at night, which is how this got started.

So, there’s the basics covered. Let’s get on to how to make some cash using this method. It is important to note that some of the companies discussed here are unlisted and are more suited to experienced investors willing to take on more risk. To cautiously summarise the outlook for CAES, it’s got a future but it’s a part of the mix – not necessarily a global game changer in itself. Battery storage is significantly more efficient, and it’s getting cheaper really fast. That’s a big threat to CAES’ ability to scale. However, what’s great about CAES is that it’s very cheap to build. There’s always going to be a place in the energy mix for “peaker” technologies – that are expensive to operate but cheap to construct. CAES fits nicely into this category.
So how would I recommend you play it? Well the technology itself is pretty basic, and it's far harder to get any patent protection on the core techniques than it is for, say, next-generation solar. Nevertheless, there are a few investments you might like to consider.

For the slightly timid, Gaelectric is a supplier that really “gets” storage. It's got investment in battery arrays (courtesy of Tesla), flywheels and their big CAES salt chambers (discussed above). Gaelectric will give you exposure to a variety of both conventional cash-cow energy plays, and also the know-how that comes from developing its own technology. It's likely better than working with a larger utility, which doesn't necessarily have the exposure to really focus your money hard on CAES.

If you’d like to take a risk on a minnow, look at the UK’s own Highview. It's LAES technology is based on bog standard liquid nitrogen, not straight compressed air. Therefore, it can be used anywhere – so no caves required. What's more, it can make use of waste heat (or cold) from any industrial processes – essentially getting some of its energy for free. Highview's technology is also great for boosting power plants – saving the cost of building expensive, semi-redundant “peaker” power plants to cover spikes in demand. Highview is leaving the demonstration plant stage and is into its first scale build. My view is that the jury is out on which of the technologies will ultimately have the cost edge, so I’d look for flexibility of deployment over efficiency. Likewise, the UK firm Isentropic has a PHES solution that also clips neatly on to existing gas-fired power stations – but can also stand alone in a renewables world.

If you're after something a little unconventional, or energy just isn’t your sector, keep an eye on PSA Peugeot Citroën. It's bringing out a compressed air car soon. This is old technology, and it's been used in mines for decades (you can't burn petrol in a mine). However, it could end up giving battery-powered cars a run for their money. It's certainly a gamble – but potentially a very profitable one. Remember how Boeing got started by going “all in” on a new technology (in its case, it was jets)?

If you're more comfortable with pure technology plays in renewables support, you've got the luxury of choice. Hydrostor and Nimrod offer technology to support generators and grids that are coastal or offshore. They use inflatable bags under the ocean to store power, so there's no need for a cave. In countries with a lot of coastline, it's an excellent technology approach.

Alternatively, SustainX (already backed by Rockport Capital and Polaris Venture Partners) and LightSail Energy are well worth a good look – because they use small(ish) gas tanks, not huge caves, to store their energy. This makes it ideal for small-scale applications, and I can imagine them flogging their 4MWh shipping containers to every African village with a solar panel in a few years’ time. There's going to be a couple of billion people hauling themselves out of poverty on the back of cheap renewables, and that super-flexible storage is really big news. I think that the advantage of shipping-container scale pushes the others into second place, behind these modular firms – but do keep an eye on the prices charged, as this new CAES technology hits the market. SustainX and LightSail do have a brilliant concept – but they have to remain competitive to survive and grow.
Smooth and powerful: flywheel technology

As more and more badly-behaved renewable energy gets added to the grid, there will be an increasing market for technology to control its feisty habits. This will give a big boost to short-term power management kit – designed for regulating output on a timescale too fast for batteries to be an effective solution (as batteries don’t like rapid charge-discharge cycling). This is particularly interesting as that a lot of this new equipment may end up getting adapted for longer-term daily power storage. This could give the reliable old lithium-ion cells we’re used to a run for their money in the energy storage market.

First: a quick recap on why this is needed. Gusty wind and cloudy skies tend to make renewable power a bit sketchy. One minute it’s on, the next it’s off. Power companies don’t like that. Consumers don’t like that. And the grid really doesn’t like that. Something needs to be done to bring the unruly renewables into line. By buffering the power generated on the timescale of seconds to minutes, low-capacity, high-power storage keeps this messy generation capacity useable. Over the timescale of hours, when the sun goes down, we then need a high-energy storage device to get us through till dawn. While the tech we’ll consider below isn’t necessarily optimal for that, it’s certainly a possible future application – if things go well.

Secondly: a note of caution. While the principles behind this tech are certainly well understood (it’s been used for over a century), its development for grid power is novel. These are high-risk opportunities!

Now: on to the technology – and the firms that will allow you to profit from it.

Let’s get started with flywheels. They’re fascinating, but at the moment pretty niche. You may be familiar with the technology, as you’ve got one in your car. Without it, your engine wouldn’t run smoothly. A flywheel is just a heavy disc that spins. It’s hard to get it spinning, and it’s hard to stop it once it’s going – like a roundabout full of kids. That inertia means it can act like a battery, storing energy for a short period of time.

To make a flywheel work efficiently, you have to mess about with the mechanics.

Firstly, you have to make it very big. A grid power flywheel is about the size of a rowing boat – and the one in your car is only about the size of a laptop. Secondly, you have to make it spin very fast – about the same speed as the flywheel in a Formula 1 engine (but that’s tiny by comparison). Thirdly, you have to remove every last bit of friction you possibly can, as grid flywheel is usually magnetically levitated in a vacuum. Fourthly, you have to shield it carefully (usually by burying it), because if it breaks it basically explodes!

Flywheels have one huge advantage in power storage and one minor one. The huge advantage is that they’re very robust. They can be spun up and down well over 100,000 times. If your phone battery could do that, it would last three centuries! This makes flywheel technology ideal for the second-by-second tweaking of grid power, to bridge awkward supply glitches. The more minor advantage is that they’re very quick to respond – delivering high power in a heartbeat.

Flywheels for electricity storage are a pretty novel technology, and the most prominent company in the field has had a pretty sketchy history. Beacon Power actually went bust in...
2011, but got salvaged by Rockland, and now sits as a wholly-owned subsidiary. You can
invest in their customers – but remember: this tech will be a small component of utility firms’
exposure. Schwungrad Energie Limited and Gaelectric are using their equipment in Éire and
Northern Ireland, respectively. A very young rival, with some seriously cool tech, is Velkess.
They specialise in making cheap, low-precision flywheels, which have clever vibration
damping technology – thus performing on a par with precision-engineered rivals.

But flywheels aren’t the only game in town. You might be familiar with an entirely different
type of storage – the capacitor. These are a mainstay of even the simplest electrical
construction kits, and they are used in most electrical equipment in one form or another.
They’re traditionally thought of as a neat way to store tiny amounts of energy and to smooth
out tricky current spikes. It’s these abilities that make them useful for everything from
starters for strip lights, to the bass and treble controls on your audio amplifier.

But in principle, there’s no reason why capacitors can’t be scaled up to fulfil the needs of
far larger customers. After all, we pump entire lakes full of water to store energy to balance
the grid. A bank of very large capacitors may not be so outlandish, after all. Capacitors are
already used in some high-power portable energy storage applications, such as buses. But
they haven’t anything like the range of Li-ion vehicles (like those used in Tesla’s cars) as they
only store about 3% of the energy of Li-ion batteries, per kilo).

However, they charge very fast and don’t suffer the short lifetimes of most battery
technologies – which every mobile phone owner experiences, after a few months. Both of
these facts favour capacitors’ use for high-power, low-storage grid applications – basically
sorting out any short-term mess on the grid. Size and weight doesn’t really matter for this
application – just build a bigger building to put them in.

But there are moves afoot to develop asymmetric capacitors (perhaps best thought of as a
halfway house between a battery and a capacitor), that’s ideally suited to longer-term use.

As a brief aside here, take a look at what Drexel is doing. It’s academic research at present but
very interesting. They’re making a flow capacitor – much like a flow battery, but a capacitor.
This will give capacitors access to the longer-term energy storage markets, if it can be
commercialised.

So what’s the verdict on these technologies? Both flywheels and grid-scale capacitors are
currently far behind Li-ion batteries, when it comes to both longer-term storage and scale
for storage applications. But with the increasing need to deal with power fluctuations in the
short term, they both have a bright future. Short-term grid storage and smoothing is certainly
a very interesting market, and one that’s likely to benefit strongly from future trends towards
renewables. However, almost all the firms involved are delicate, newborn lambs – and there
are a lot of wolves around, not least Tesla. Proceed with caution.