A balancing act

Why renewable energy grids need modulating aluminium smelters, by **Geoff Matthews***

Since the first power station was commissioned in 1882, a simple industrial-age mechanical device, the steam valve, has been used to keep our energy grids in balance without the need for storage.

The rules were simple. Exactly the same amount of active power must be generated as is being consumed – a balanced system. By opening and closing steam valves, and spinning turbines faster or slower, thermal power stations have been able to supply exactly the right amount of power as was being consumed at any given time, thus providing reasonably stable energy grids to forge ahead and build a modern world.

Our modern world has come at a cost

It doesn't matter if you believe that man-made climate change is real or not, the point is enough people believe it's real to seek a low emissions future, and to drive real change. For most countries, reducing CO_2 emissions is reliant on clean renewably sourced energy.

We have all heard the catch-cry that renewable energy sources are disrupting our energy systems, but do we really understand what this means? More importantly, what does it mean for us, both as people of the earth, and as people involved with primary aluminium production?

The balance of power has changed

With renewable energy sources (particularly solar and wind), there is no steam valve in the process. Electricity generated from these sources flows directly into the grid, making it more difficult for power generators, and the lines companies, to control the process.

Dr. Abhisek Ukil, Senior Lecturer at the University of Auckland, and an expert in disturbance analysis in power systems, sums it up succinctly when he says, "you can't control nature".

The rules have been broken, and in the future it is going to be up to us, the consumers of energy, to help fix the problem and maintain balance in the system.

Two years ago, I was one of a number of people interviewed for a think piece entitled 'Power to the People'[1], the think piece sums up by saying, "we must fundamentally change the way we consume power."

Disruption

The disruption to our energy systems we hear and read about is mostly related to the existing business models of power generators and transmission lines companies, and what will happen to their stock values. This bit is not that interesting, or difficult to predict; they will have to reinvent themselves and become consumer focused, or they risk going bust.

The interesting bit is what was discussed in 'Power to the People'; if we are to have a low emissions future, then energy consumers will be required to adopt new technologies and change their behaviours, so that they become an integral part of the stability of the grid.

This leads to the really interesting bit for those of us in the primary aluminium business; how much will the power companies pay us to balance the grid for them? They even have a name for this, the Energy Imbalance Market (EIM).

What change looks like

It's possible that no one on the planet will be unaffected by the changes to our energy systems over the next 20 years.

From the remotest villages to the shining glass towers of our most modern cities, when it comes to energy, all of us will be subject to the forces of three converging economic and technical paradigms, all being driven by the desire for a low emissions future. They are:

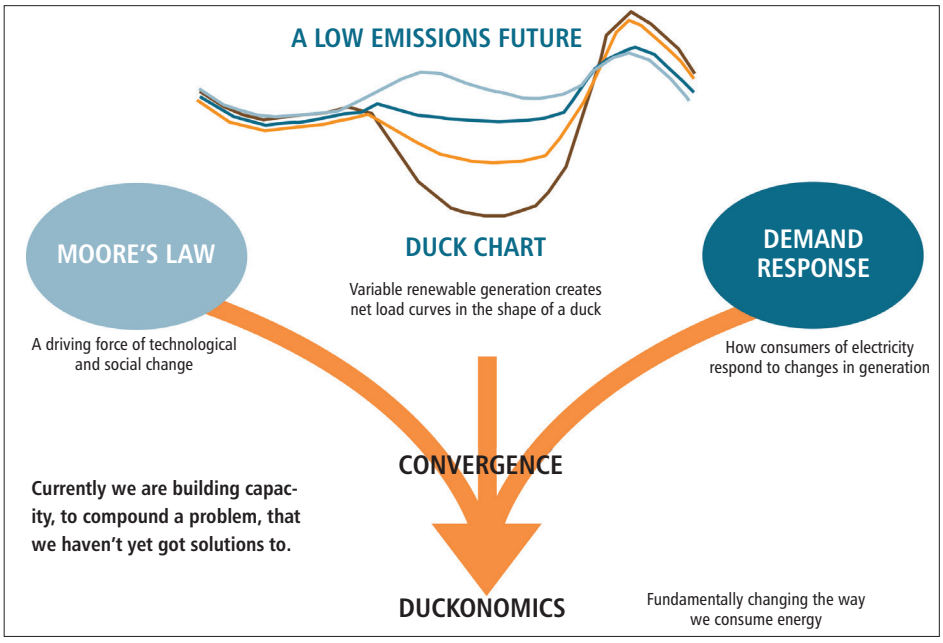
- Moores-Law, and how it applies to renewable energy generation
- The Duck Chart, which are the net load curves caused by the lack of a steam valve
- and Demand Response, which is how consumers respond to changes in generation.

I refer to this convergence as 'Duckonomics'.

Looking at the next 20 years, when it comes to energy systems, it's hard to see how 'Duckonomics' won't dominate our discussions, policy decisions, energy systems investment, and our adoption of new technologies. It's worth taking a little bit of time to better understand how these paradigms will affect our lives.

Moore's Law

Moore's law is the observation made by Gordon Moore, co-founder of Intel, in a



*PG Dip Mark, FCIM (UK), Vice President, Energia Potior Limited

1965 paper[2] that observed the number of transistors in a dense integrated circuit doubles approximately every two years.

Moore's law has since become far more than just an observation about microchip performance however, it is now described as, "a driving force of technological and social change, productivity, and economic growth."[3]

Moore's law has been applied to renewable energy technology, with evidence to suggest solar PV capacity per installed cost doubling every 22 months, with wind power not being too far behind, or even possibly in front. This is prompting the prediction that we will be able to generate 100% of the planet's needs from renewables in the next 20-30 years.

Whatever the true rate of doubling, it is sufficiently fast enough to confidently predict that we need to seriously deal with the net load curves created with solar PV.

The Duck Chart

Net load is the difference between forecasted load and expected electricity production from variable generation resources. At certain times of the year, these 24 hour net load curves produce a 'belly' appearance in the mid-afternoon that quickly ramps up to produce an 'arch,' similar to the neck of a duck-hence the industry moniker of 'The Duck Chart.'[4]

These conditions provide a headache for the electricity generator as short steep ramps mean they must bring on, or shut down, generation resources to meet an increasing or decreasing electricity demand quickly, to maintain grid reliability.

Demand response

Flattening the duck curve will drive technology such as household batteries, smart homes, and a host of other storage technologies and devices. Michael Liebreich, founder of Bloomberg New Energy Finance, predicts it will also lead to a two-tier electricity network, where you buy your cheap, variable power from one or more electricity providers when it is available, to store in batteries, water heaters, your electric vehicle, or underfloor heating et al, and your more expensive, dispatchable power from yet another provider when you need it.[5]

Technologically short

To compound the problem of the duck chart, is the fact is that no matter where we look, we are currently 'technologically short' across the board when it comes to technologies that can help with demand response.

Grid level batteries and storage systems, and virtual mega grids, are not with us yet. Neither are household batteries, nor the really smart systems to monitor and top up our homes. A two-tier electricity market also seems a long way off. Furthermore, transmission pricing in most countries is either 35 or 135 years out of date, depending on who you talk to.

Liebriech also worries that renewable generation will quickly saturate the market for variable power (low hanging fruit), and that deeper penetration of renewables will stall because it can't replace the harder-to-obtain and guaranteed dispatchable power. Currently, if you take a dispassionate look at it you could sum it up like this; *we are building capacity, to compound a problem, that we haven't yet got solutions to.*

How modulating the energy use of an aluminium smelters helps

1. We are technologically ready, with proven modulating technology for primary aluminium smelting that allows smelters to vary energy consumption (and therefore production) by + or – 30%.

2. Size matters. Even a medium sized aluminium smelter modulating up and down 30%, can free up, or soak up 150MW or more, enough electricity to power a small city. That's a lot of house batteries or BEVs. Having one large customer who can, at the turn of a dial, soak up excess generation, or shed load, allows an electricity generator to maintain price stability in the rest of the market, as well as grid security.

3. Deeper penetration of the market by renewables will be dependent on industries and technologies that can 'convert', or use, variable power as if it were dispatchable power. Modulation technology allows a smelter to convert large amounts of variable power into usable power, after all when it comes to the Hall-Herault process, it all makes aluminium.

4. Smelters are also ideal partners to help smooth out frequency issues and to provide reliance and stability to grids. Some smelters already participate in the Primary Electricity Market (frequency response), on a second by second basis. Such power variations don't affect the process or quality of final product, and because these power fluctuations are short-term in nature, smelters don't even require modulation technology.

A productive grid-level battery

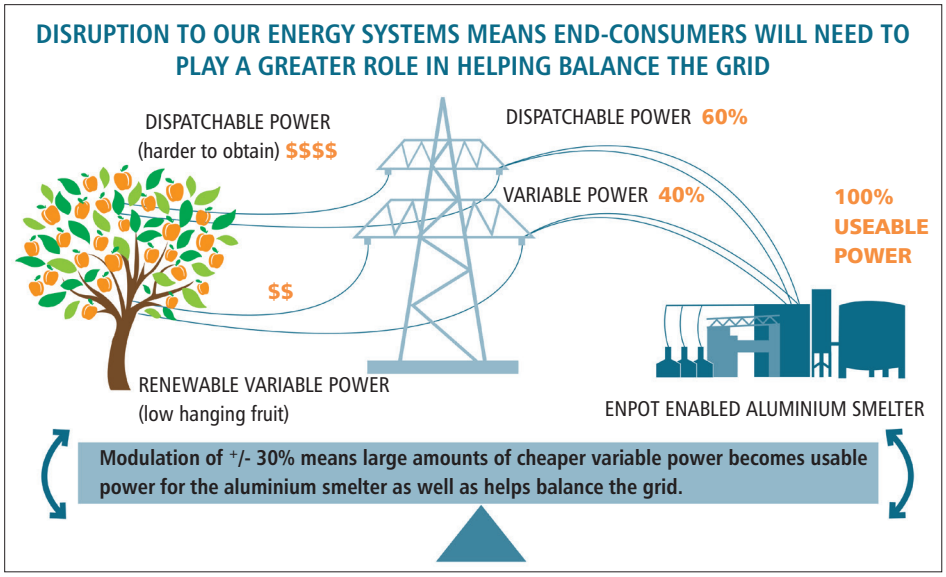
The first significant installation of EnPot Shell Heat Exchanger modulating technology was at TRIMET Aluminium's Essen smelter in 2014. CEO of TRIMET, Dr Martin Iffert, referred to the EnPot Shell Heat Exchanger system as a "virtual battery" for the grid. The term was questioned by some in online forums, especially when one article described the virtual battery as storing energy in "lakes of molten aluminium".

Therefore, I posed the question to Dr. Abhisek Ukil; "yes, an aluminium smelter fitted with modulation technology can be regarded as a grid level battery, or virtual power plant (VVP)," he says.

"The purpose of any grid-level battery is to store energy so it can be fed back into the grid when generation is low or demand high.

An aluminium smelter fitted with EnPot is essentially doing the same job as a grid-level battery. When generation is low and/or demand is high, the heat exchangers insulate the cells and maintain the heat balance of the pot, so a portion of the usual power required can be returned to the grid.

"In essence, you are just storing energy in the form of heat, rather than in a battery", Dr. Ukil says.



The International Energy Agency (IEA) Energy Technology Perspectives 2017 Report, identifies TRIMET Aluminium's use of the Virtual Battery system as a transformative technology in providing flexibility to the energy grid through demand response.

Aluminium – the beautiful metal

Dr. Mark Dorreen, Director of the Light Metals Research Centre and Vice President of Energia Potior Ltd, points out that because heat exchangers maintain the heat in the pots, they perform better than a grid level battery because the smelter doesn't require recharging.

"When full power becomes available again, the pots don't require energy input to get back up to temperature," he says.

"Batteries are also non-productive, that is they don't perform any other function than storing and discharging energy. Once a battery is charged, it is full, it doesn't do anything else. An aluminium smelter on the other hand, keeps on producing aluminium, taking the energy generated today and transforming it into metal to be stored for reuse by future generations," he says. "As we go forward over the next 2-3 decades, the appeal and desirability of taking todays renewable energy and transforming it into a metal that we can use, recycle and then reuse, over-and-over again for generations to come, will resonate with consumers," Dr. Dorreen says.

Both Dr. Ukil and Dr. Dorreen are of course referring to Einstein's law that energy cannot be created or destroyed, but only transformed from one form to another. Aluminium in its metallic form is not just an inert metal, it is storing energy for the future.

The return of aluminium smelting to the west

Over the last 20 years we have seen the migration of aluminium smelting essentially away from centres of population, and towards either isolated, or cheap sources of power.

The need for demand response over the next 20 years to stabilise the energy grids of our most populated areas may however, see expansion of aluminium smelting again in western countries. Professor Basil Sharp, Chair in Energy Economics the University of Auckland, says the proposition of aluminium smelters integrating with energy grids, "arguably makes sense, especially as grids seek to increase the percentage of power generated from renewables."

"Duckonomics is a real challenge for transmission lines companies, who see the value of their assets under threat. Essentially, by being able to modulate to such an extent you are turning variable power into dispatchable power," he says.

"It will also be appealing for power generation and transmission lines companies to deal with one large partner, such as an aluminium smelter, to help maintain both price and grid stability to the domestic consumer base," Professor Sharp says.

Dr. Dorreen also points out that the economics of smelting in the west may also changing. "Given the recent resurgence in the aluminium metal price, it is understandable that many idled western smelter operations are being considered for restart.

"The addition of modulating technology to these smelters would allow for new types of energy contracts between energy providers and the smelters, and should add to the attractiveness of the business case, in particular in regions such as mainland USA," he says.

Change is with us

We have to accept that we cannot change what we cannot control, but at the same time, we need to learn to change what we can. We may not be able to control nature, or the forces driving a need for a low emissions future, but we now can control how our aluminium smelters consume energy. Maybe we can learn how to use duckanomics to work in our favour, and not against us. We live in interesting times. ■

References

1. Power to the People, author, Dr. Linda Wright.
2. Cramming more components onto integrated circuits.
3. https://en.wikipedia.org/wiki/Moore%27s_law.
4. www.caiso.com, Flexible Resources Help Renewables Fast facts.
5. Six Design Principles for the Power Markets of the Future – A Personal View by Michael Liebreich, Chairman of the Advisory Board Bloomberg New Energy Finance