The New Power Cost League Table

A clear view of the consumer cost of new build power stations

July 2016

TIDAL LAGOON POWER

Contents

Welcome

We are pleased to introduce the inaugural issue of the UK's New Power Cost League Table.

Why did we develop this? Simply put, the UK has a looming electricity generation deficit. We wanted clear answers about the relative costs of new generating capacity. **This means a focus on the incentives required to attract investment to deliver the electricity we are going to need.**

All new power plant construction requires guaranteed revenue from electricity sales, these days largely in the form of a contracted 'top-up' over the wholesale market price that attracts the necessary up-front investment. This top-up, negotiated by Government, is in effect borne by bill payers.

Are these deals good? Are they terrible? We can only tell by comparing trends across the different contracts, over time, using a consistent approach.

Hence this League Table – the first ever 'apples-to-apples' comparison of enabling contracts and their **lifetime consumer cost for each delivered megawatt hour of electricity**. Looked at this way, there are some surprising differences to the prevailing narrative.

We have provided full details about the methodology and supporting data. We look forward to your input, and views on how we can make this study even better going forward.

Keith Clarke CBE
Non-Executive Chairman

The power deficit context

By 2030 the UK will have closed 82% of its existing fossil fuel based power station capacity. At the same time electrification policy calls for electric trains, electric heat pumps and more electric cars – all net new demand.

Paying for new power stations to replace this deficit means power will be more expensive than that from old power stations, long paid-off, no matter what technology is employed.

The UK Government has to incentivise all new build through a variety of enabling contracts that pay the generator a premium over the wholesale cost of power. This premium is ultimately borne by the UK bill payer.

This study captures key variables and presents the consumer cost associated with each decision to back a new power station.

Power Deficit in Numbers

85GW
INSTALLED CAPACITY

20GW
ELECTRIFICATION DEMAND
(TRANSPORT, HEAT, ETC.)

+

38GW
GOING OFFLINE
(COAL ETC.)

=

58GW
TOTAL NEW CAPACITY NEEDED

–

18GW
CONSENTED CAPACITY
(NUCLEAR, TIDAL, WIND, ETC.)

–

8GW
INTERCONNECTORS
(NOT YET CONSENTED)

=

32GW
THE POWER DEFICIT

Cost questions we addressed

What will each enabling contract (issued and forecast) cost the bill payer over the life of the technology? We expressed this as a single number, directly comparable across technologies.

How have these costs evolved over time as technology has evolved and Government has introduced new support mechanisms?

What effect does the future wholesale power price have on the level of bill payer support received by different technologies?

What other factors affect the 'value' of power and the decision-making of Government?

Network characteristics of new UK power sources

Onshore Wind
Radically improved predictability with forecasting. Flexibility generally only in discarding power, not ramping up power

PREDICTABILITY	MODERATE
FLEXIBILITY	LOW
LIFESPAN	24 YRS

Solar PV
Solar output is variable on a daily basis with limited control – it is embedded in the distribution networks – National Grid has no sight of its behaviour

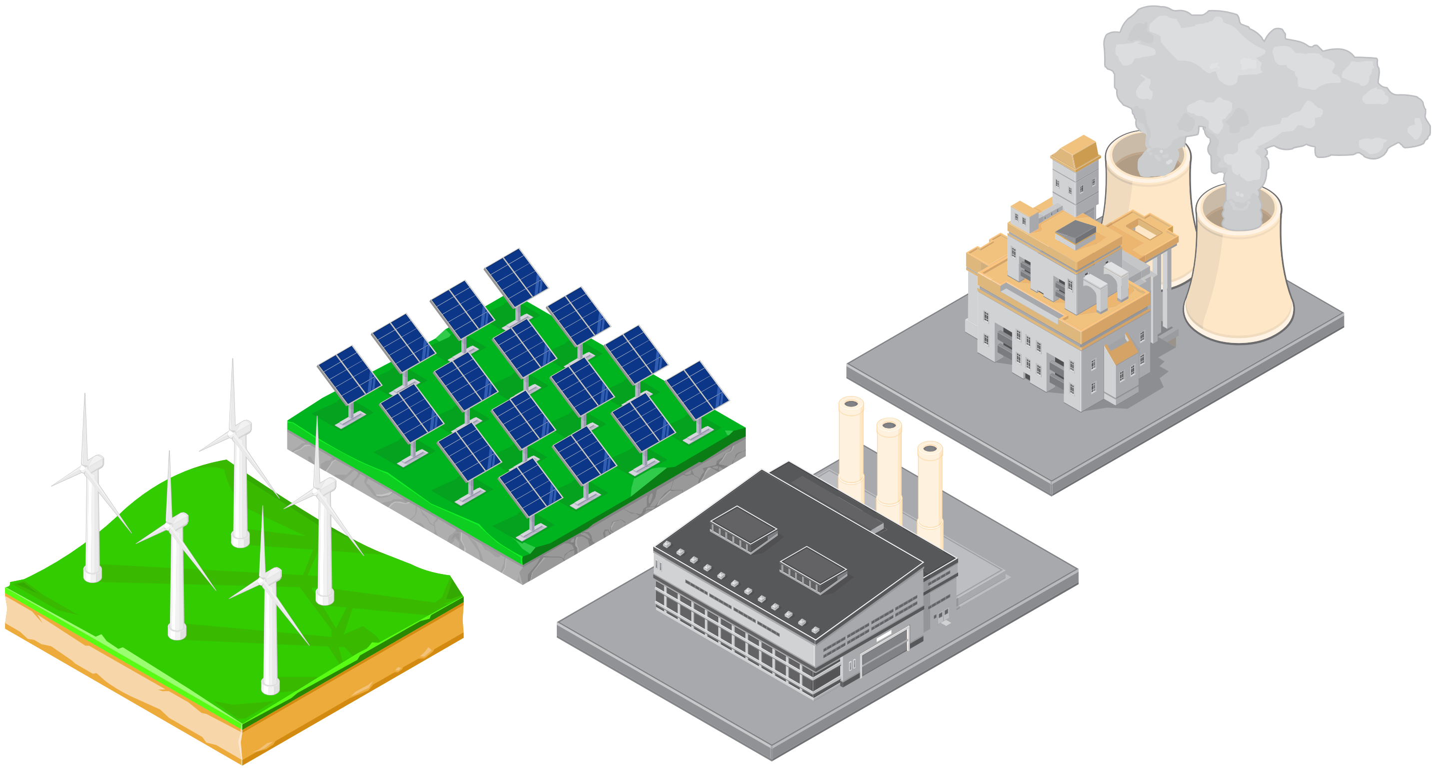
PREDICTABILITY	MODERATE
FLEXIBILITY	VERY LOW
LIFESPAN	25 YRS

Combined Cycle Gas Turbine (CCGT)
Reliable, and highly flexible generation. Although 14 stations are permitted, no new CCGT stations are being constructed due to exclusion from the CfD mechanism and reducing load factors with continued renewable development

PREDICTABILITY	HIGH
FLEXIBILITY	VERY HIGH
LIFESPAN	25 YRS

Nuclear
The most reliable of all low carbon generation. Nuclear power is reliable baseload but it is inflexible, causing incompatibility issues with wind and solar

PREDICTABILITY	VERY HIGH
FLEXIBILITY	LOW
LIFESPAN	60 YRS



Tidal Lagoons

Highly predictable due to known tidal cycles. Lagoon technology is also flexible due to variable speed turbines – lagoons can help to facilitate the integration of further intermittent wind and solar capacity with inflexible nuclear

PREDICTABILITY
VERY HIGH
FLEXIBILITY
HIGH
LIFESPAN
120 YRS

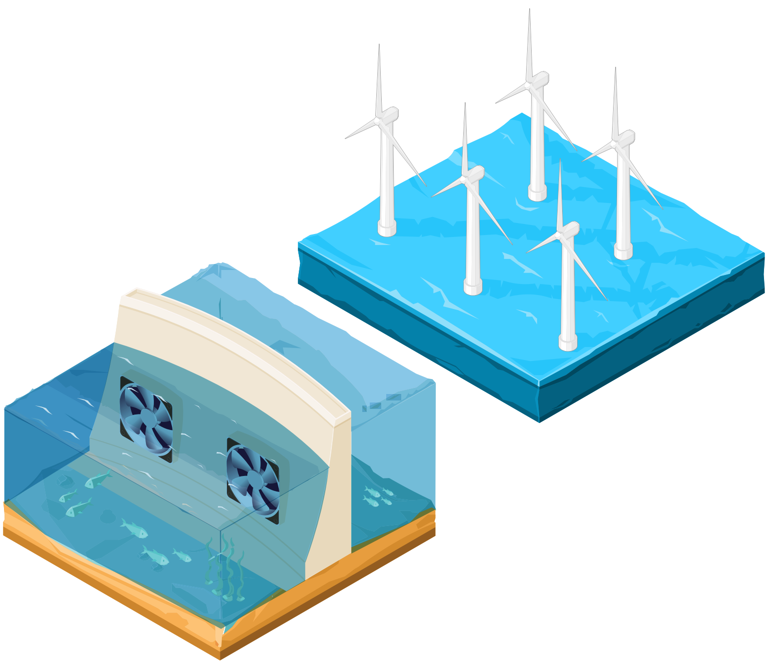
Offshore Wind

More reliable than onshore wind. Flexibility generally only in discarding power, not ramping up power

PREDICTABILITY
MODERATE
FLEXIBILITY
LOW
LIFESPAN
22 YRS

Our View

The UK needs a diverse mix of generation to provide power security, predictability and flexibility. This is best achieved through a backbone of large, predictable, zero carbon power stations supplemented with smaller modular renewables. Significant energy storage development will facilitate further expansion of low carbon generation and reduce the need for back-up CCGT capacity.



Methodology overview

The UK's National Grid must manage a mix of different technologies, each with different characteristics.

A nameplate megawatt of wind or solar produces electricity intermittently.

A nameplate megawatt of nuclear power is reliably constant, producing electricity most of the time.

Hence we modelled the consumer cost for each **delivered** unit of electricity, a megawatt hour, for each technology, using accepted load factors.

The key number is the Net Present Value (NPV)* of the consumer cost per delivered megawatt hour.

***NET PRESENT VALUE**
Widely used method of presenting future money in today's terms. The value of money in the future is discounted each year to bring it into a present value. The further in the future money is paid or recieved, the less value it has today.

Step-by-step

1. Published contract rates

We took published data about enabling contracts since 2012 – for solar, onshore and offshore wind, new nuclear, and biomass conversion, as well as data submitted to Government for tidal lagoons. We also added forecast rates for future offshore wind and gas.

2. Net present value of those payments

We valued the future cost of these enabling contracts in today's money, taking into account DECC's long term wholesale power price forecast, using the same assumptions employed by HM Treasury to assess large projects.

3. Forecast power generation

Then we assembled published data about the lifetime and 'load factors' of different technologies in order to calculate how much electricity they will generate over their lifetimes.

4. NPV of generation

We applied the same valuation techniques to this future electricity generation to align its value with the cost of the enabling contract in today's terms, in the same way HM Treasury does.

5. Relationship between cost and power

We then considered the present cost of the enabling contract against the present value of the electricity received in return.

6. Publishing and comment

We are publishing the assumptions used in the model. We will be happy to run additional sensitivities in the model on request.

OUR NET PRESENT VALUE SUM EXPLAINED

DECC historical agreements
Plus other inputs

NPV of total consumer cost

÷

Nameplate capacity
Load factor
Anticipated lifetime for each power source

NPV of total power output

=

NPV of consumer cost/MWh

Questions & answers

Why incentivise in the first place?
Even without a decarbonisation agenda, significant new capacity would have to be built since we have under-invested for many years and old plant need to be replaced. All of the options are more expensive because they are new build, not because they are low carbon. Investors need confidence they will get their money back and make a return, so they have to be guaranteed a price. State aid is typical in the construction of power stations – the existing UK coal and nuclear fleet was actually built and paid for by the UK Government.

Why should consumers subsidise the construction of power stations?
Consumers are required to contribute to the cost of replacing the UK's ageing fleet of power stations because a failure to build them would result in even higher energy bills and an insecure supply of electricity in return. As old plant drop out of the system, demand would far outstrip supply and prices would escalate accordingly.

Government has addressed the failure of the market to bring forward new power stations by establishing a pricing framework to attract the investment required to build them. Consumers contribute to the additional cost via their electricity bill. This is often presented as a form of subsidy but the reality is that the consumer cost of inaction would be higher.

Why not focus on wholesale cost?
Current wholesale power prices (£39/MWh, averaged over the past 18 months) reflect the fully depreciated cost of old power plant. No operator will build large scale capacity if the power is sold at these low rates. The mechanism for incentivising new power plant is to contract a higher guaranteed price level, a top-up to the expected wholesale price. This top-up is the cost ultimately passed along to bill payers – the focus of this study.

Why not use headline strike prices as a basis of comparison?
The strike price is an agreed guaranteed price for power during a contract term, typically fully indexed and expressed in 2012 terms, which includes the revenue earned from the wholesale market. What we are focussing on is the consumer component of that cost, because this is what Government is paying as a top-up over the wholesale price, passed back to bill payers.

Headline strike prices also fail to capture alternative financing structures that can be used on long-life assets, such as tidal lagoons, which can reduce the top-up element over time. We also assess other support mechanisms here, such as FiTs and FIDeR, bringing all these different contracts into alignment and allowing direct comparison.

Why not use Levelised Cost of Energy analysis?
'LCOE' examines the operator's up-front and operational costs of building power stations. This helps to tell investors what price they need to achieve from a contract to make a sufficient return. It's very useful, but does not delineate the actual cost to bill payers. Nor does it recognise alternative financing structures for long-term assets.

I hear that some solar could be built at no cost the consumer?
It is likely that, in the near future, developers will construct zero-support solar power stations. This is a major achievement for the renewables sector but will depress the wholesale markets when there is an abundance of solar energy, ultimately increasing the consumer cost for technologies that require contracts. Solar is inflexible and unable to provide energy during winter peaks. It doesn't address the capacity deficit – we still need other power stations.

Why only large sources? What about small, decentralised power?
There is a role for decentralised power and we expect to see more, but the UK still needs a backbone of large, low carbon power plant. We focused on the major technologies capable of delivering electricity at a national scale – those expected to soon deliver over 2GW of installed capacity.

What about energy storage?
With the introduction of further energy storage, the potential for increased renewable generation is significantly expanded as intermittent power can be stored and released when needed. The technology and network have challenges to overcome before storage can provide a full solution.

Glossary & sources

Glossary of terms

£/MWh: GBP per unit of delivered energy, a megawatt hour. There are 1,000 kilowatt hours (kWh) in one megawatt hour (MWh).

FiT: Feed-in Tariff. Introduced in 2010, FiTs provide a fixed payment, from UK Government to renewable generators, on top of what they earn on the wholesale market, regardless of power prices.

FIDeR: Final Investment Decision Enabling for Renewables. A bridging support mechanism between previous approaches and CfDs, based on a strike price.

CfD: Contracts for Difference. The UK Government's new support mechanism for low carbon energy. The UK Government agrees to pay generators a top-up to a fixed strike price, after accounting for what they earn from the wholesale market. If power prices exceed the strike price, the generator pays the excess back to UK Government.

Strike Price: The agreed level at which UK Government enters into CfDs. Strike Prices are technology and project dependent.

New nuclear: Modern nuclear power stations, yet to be built. EDF's Hinkley Point C is currently the most advanced project and has agreed a CfD.

CCGT: Combined cycle gas turbine. Modern gas-fired power stations.

Load factor: A measure of a power station's availability and efficiency, technology specific.

Capacity payment: A payment for availability of power rather than delivery of electricity: GBP per MW rather than MWh. Capacity payments reflect the value of firm availability and security of supply.

Data Sources

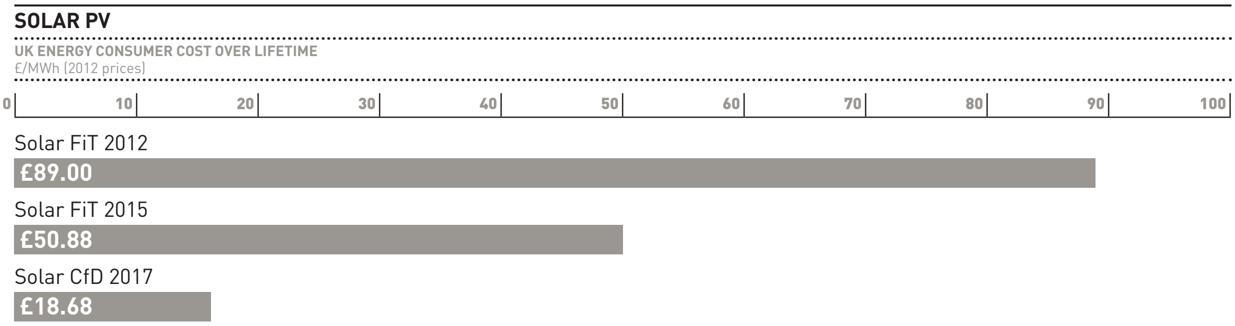
- Published data from the Department of Energy and Climate Change (DECC)
- Published data from Ofgem
- Latest confidential data from Tidal Lagoon Power, currently under review by DECC

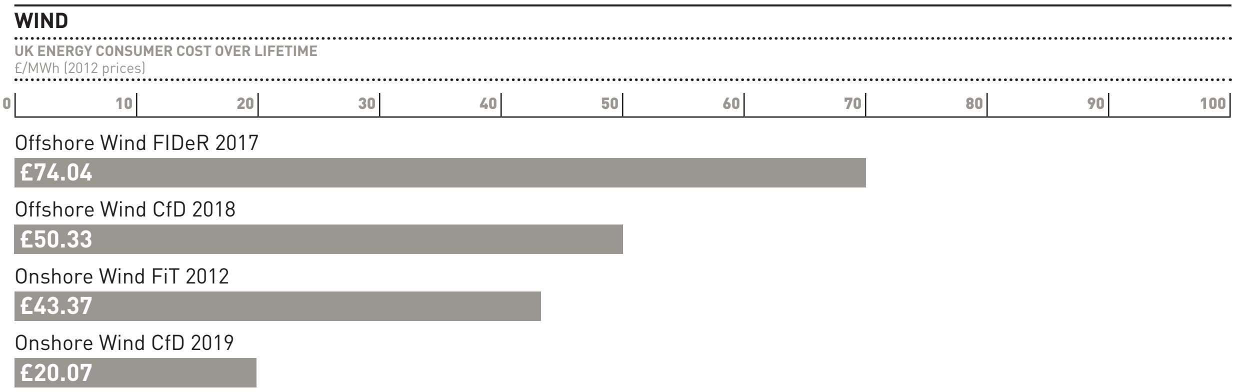
Comments and caveats

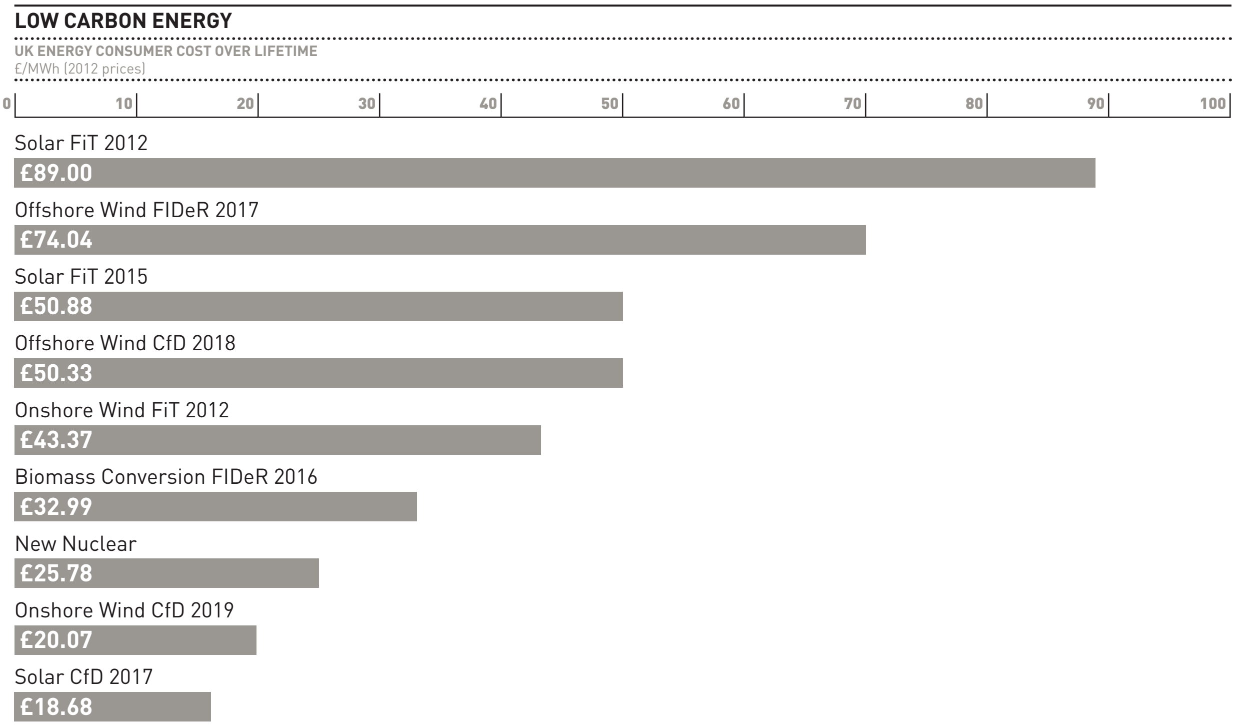
- Grid management costs are not included. These can be significant for unpredictable intermittent sources like wind and solar and for inflexible sources like nuclear. Flexible technology may attract a premium for its value in providing grid management services
- Decentralised power, storage and sources with under 2GW of installed capacity are not included
- Off-grid, commercial and military generation is not included

Downward trend of enabling contracts

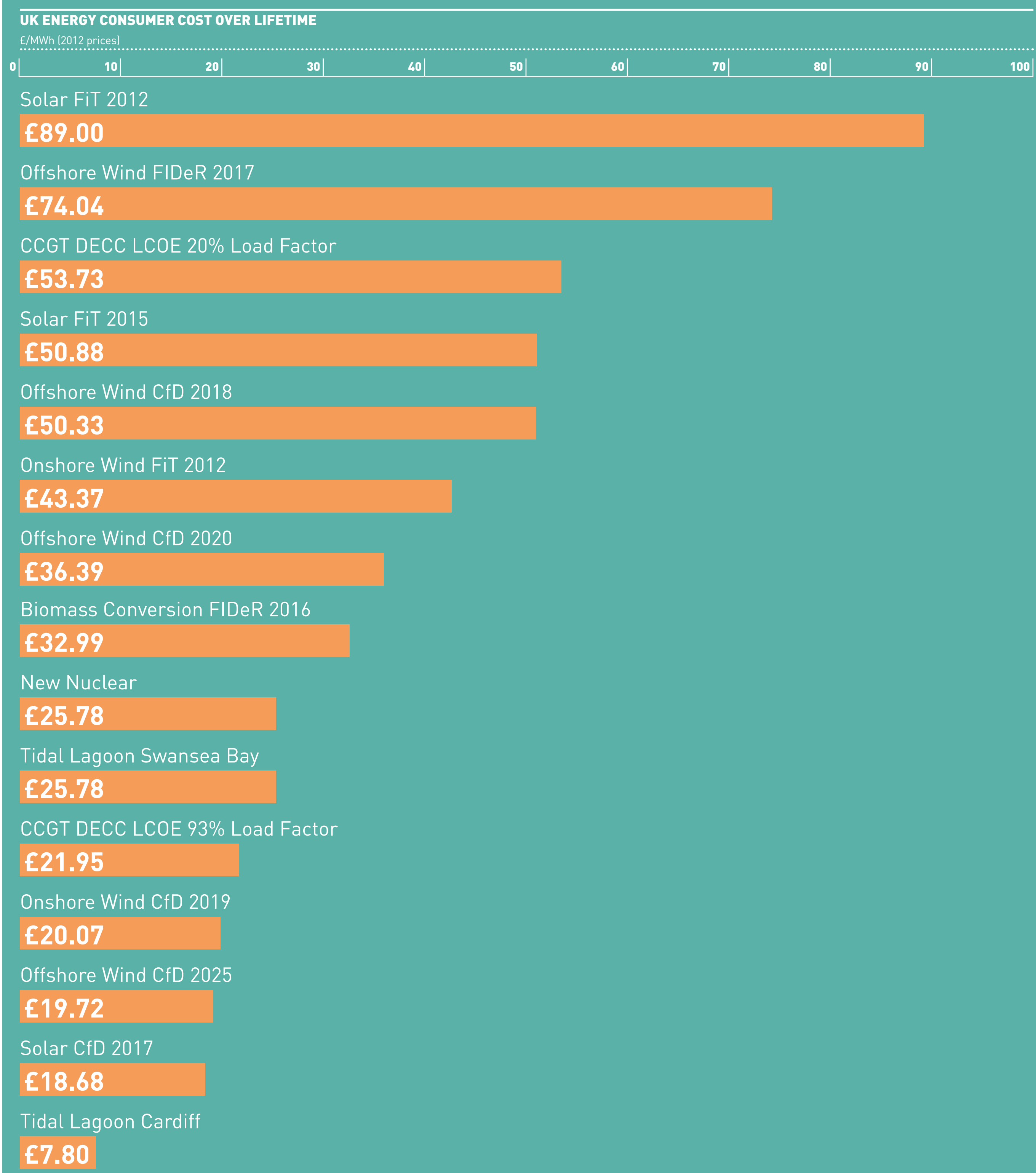
Overall, there is a clear trend of reducing costs over time in low carbon energy







The New Power Cost League Table 2016



Main takeaways

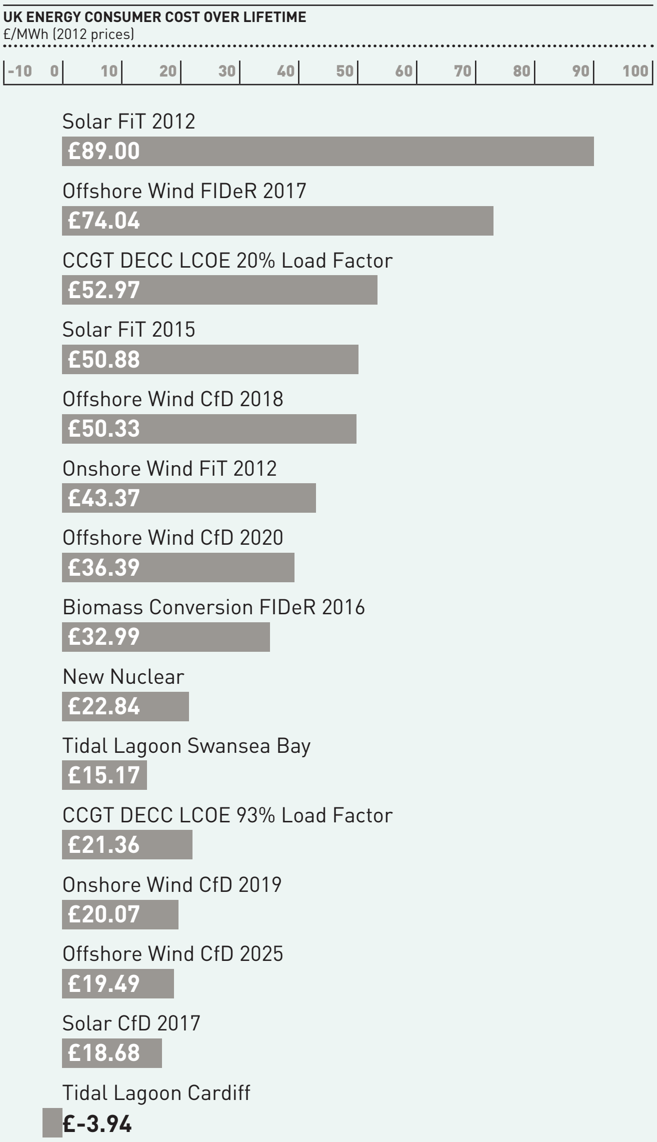
1. The UK must address a looming power deficit by investing in new power stations
2. All new power stations will pass a cost to energy bill payers, irrespective of the technology employed
3. By examining the actual consumer cost of enabling contracts against the actual power returned, the New Power Cost League Table provides a clear view of the consumer cost of new build power stations
4. The ‘premium’ for new build, low carbon generation is reducing as old enabling contracts are replaced by new, more competitive contracts
5. Wind and solar have seen significant reductions in their consumer cost since the first contracts were issued
6. New nuclear power and the pathfinder tidal lagoon at Swansea Bay are coming in on-trend
7. New build gas-fired power stations are only competitive if high load factors can be achieved
8. The first large scale lagoon at Cardiff generates the cheapest electricity of all new build power stations
9. Not all low carbon generation is equal – the grid needs a mix of low carbon sources with different characteristics
10. Reliability, flexibility and storage will become increasingly valuable as more intermittent sources come online in the transition to a low carbon electricity system in the UK

Flexing the assumptions

We used the UK Government's long term reference scenario for the cost of wholesale power in the future. This looks out to 2035, after this point we assumed the cost remains the same. We flexed these assumptions up and down to see how the results changed.

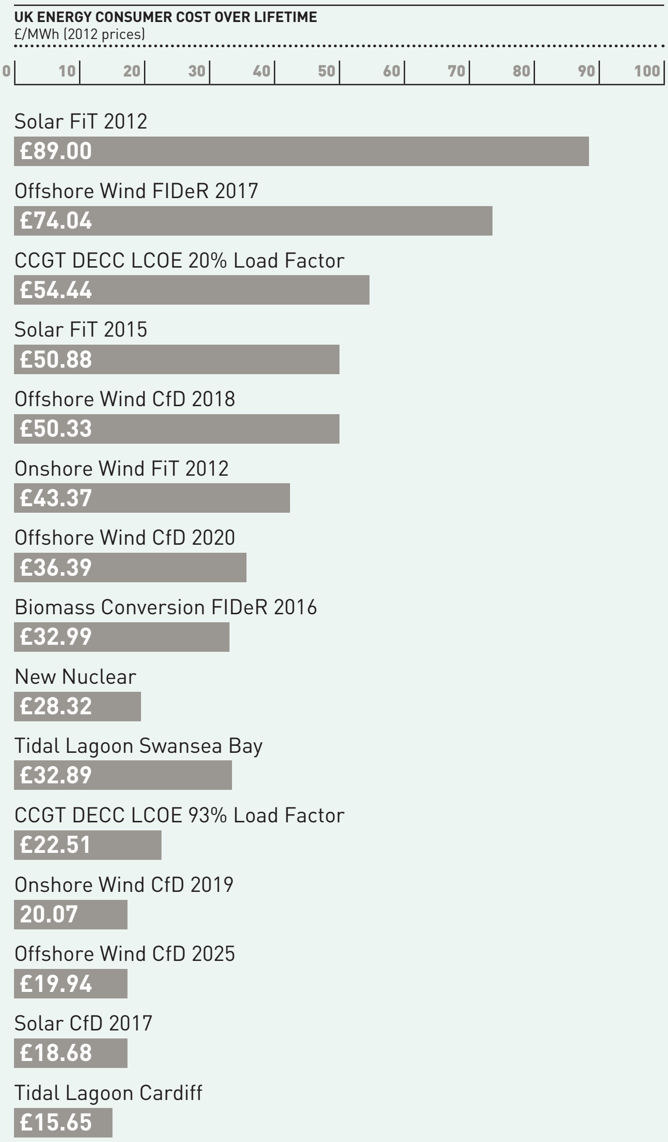
1% annual increase in wholesale cost of power from 2035 onwards

In a world where power prices increase above the base case after 2035, consumer costs overall are lower as more revenue is claimed through the wholesale power market. Larger tidal lagoons can be built at zero net cost to the bill payer.



1% annual decrease in wholesale cost of power from 2035 onwards

In a world where power prices decrease below the base case after 2035, all generation requires greater support from bill payers as less revenue is captured from the wholesale power market. In this scenario it's likely that significant portions of revenue will come from capacity payments, another form of consumer cost, not accounted for in this analysis.



Analysis assumptions

Technology assumptions	
Load factors	**%**
Solar PV	11.1
Onshore Wind	26.7
Offshore Wind	37.7
Biomass Conversion	64.5
New Nuclear	91.0

Lifetime	**Years**
Solar PV	25
Onshore Wind	24
Offshore Wind	22
Biomass Conversion	22
CCGT	25
New Nuclear	60
Tidal Lagoon	120

Wind/Solar Hourly Price Discount	4.0%
CCGT 20% Load Factor Hourly Price Premium	27.0%
Power Curve	DECC 2015

Contract details 2012 prices	**(£/MWh)**
Solar FiT 2012	89.00
Solar FiT 2015	59.00
Solar CfD 2017	79.23
Onshore Wind FiT 2012	49.00
Onshore Wind CfD 2019	82.50
Offshore Wind FIDeR 2017	150.00
Offshore Wind CfD 2018	119.89
Biomass Conversion FIDeR 2016	105.00
New Nuclear	92.50
Offshore Wind CfD 2020	105.00
Offshore Wind CfD 2025	85.00
CCGT DECC LCOE (93% Load Factor)	80.00

Notes

Discounting approach based on HM Treasury Green Book.

Power curve based on DECC November 2015 Updated Energy and Emissions Projections. Assumed flat in real terms post-2035.

Load factors derived from CfD Allocation Framework October 2014.

Technology lifetimes derived from DECC December 2013 Electricity Generation Costs.

CCGT case based on an assumed required level of support derived from LCOE figures in DECC December 2013 Electricity Generation Costs. 20% load factor CCGT receives a premium of 27% on wholesale market prices captured to reflect high-value period targeting (based on the last 24 months of market data).

New Nuclear figures based on Hinkley Point C.

Offshore Wind FIDeR figures based on Burbo Bank Extension.

Biomass Conversion FIDeR figures based on Drax Unit 1.

Offshore Wind CfD 2018 figures based on East Anglia 1.

Tidal Lagoon output based on actual energy modelling data submitted to DECC.

Tidal Lagoon support cash flows derived from alternative support structures submitted to DECC, subject to ongoing iteration.

Wind/Solar hourly price discount is designed to capture self-cannibalisation under intermittent market reference price CfDs – day ahead prices are driven lower during periods of increased forecast wind/solar output.

Inflation assumed at 2.5% from 2019.

All figures in real 2012 prices.

Analyst conclusions

1 The UK's energy mix is diverse in terms of technologies and their characteristics. This mix of solutions is necessary to achieve the sustainable and secure supply we need, at the lowest cost to consumers. Tidal lagoons, new nuclear and offshore wind can achieve this at scale and at a competitively low cost.

2 The incentivisation of low carbon energy has worked – consumer costs for wind and solar have reduced rapidly and other technologies have managed to come in on-trend.

3 New nuclear has issues, but consumer cost per delivered MWh isn't necessarily one. Consumer cost per MWh is on-trend with other power stations but concerns over capital cost, construction programme and year of delivery mean the UK needs a backup plan for large scale, low carbon capacity.

4 Power station lifetime makes a difference – longer life projects pass less cost to consumers as they can be financed under longer, more efficient structures. We need a mix of power station lifetimes and associated duration of enabling contracts.

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A Cambridge graduate, Mike has 10 years of low carbon power experience in venture capital, project development and economic and financial analysis.

What does this mean for tidal lagoons?

The UK needs new power stations. Under this apples-to-apples analysis, tidal lagoons are shown to be a competitive option in the development of new power station capacity in the UK. The pathfinder project in Swansea Bay (320MW) comes in on-trend, at the same level as new nuclear. The first large scale tidal lagoon, Cardiff (~3,000MW), represents the cheapest electricity of all new build power stations.

Towards the future system

As the UK system evolves, the management of supply and demand must adapt to reflect the characteristics of the future system. Energy storage, demand side management and plant flexibility will play an increasingly important role.

Tidal lagoons can provide predictable, zero carbon electricity at scale. They can be brought forward quickly: construction takes years, not decades. Their output can be modulated in order to provide balancing services. A portfolio of tidal lagoons in multiple locations around the UK coast, with different tidal cycles, has the potential to provide round the clock grid management services. This facilitates the integration of intermittent wind and solar with inflexible nuclear, paving the way to a low carbon future for the UK.

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